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Forest Restoration of Lincoln Boyhood National Memorial: Presettlement, Existing Vegetation, and Restoration Management Recommendations

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Midwest Region

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By Noel B. Pavlovic
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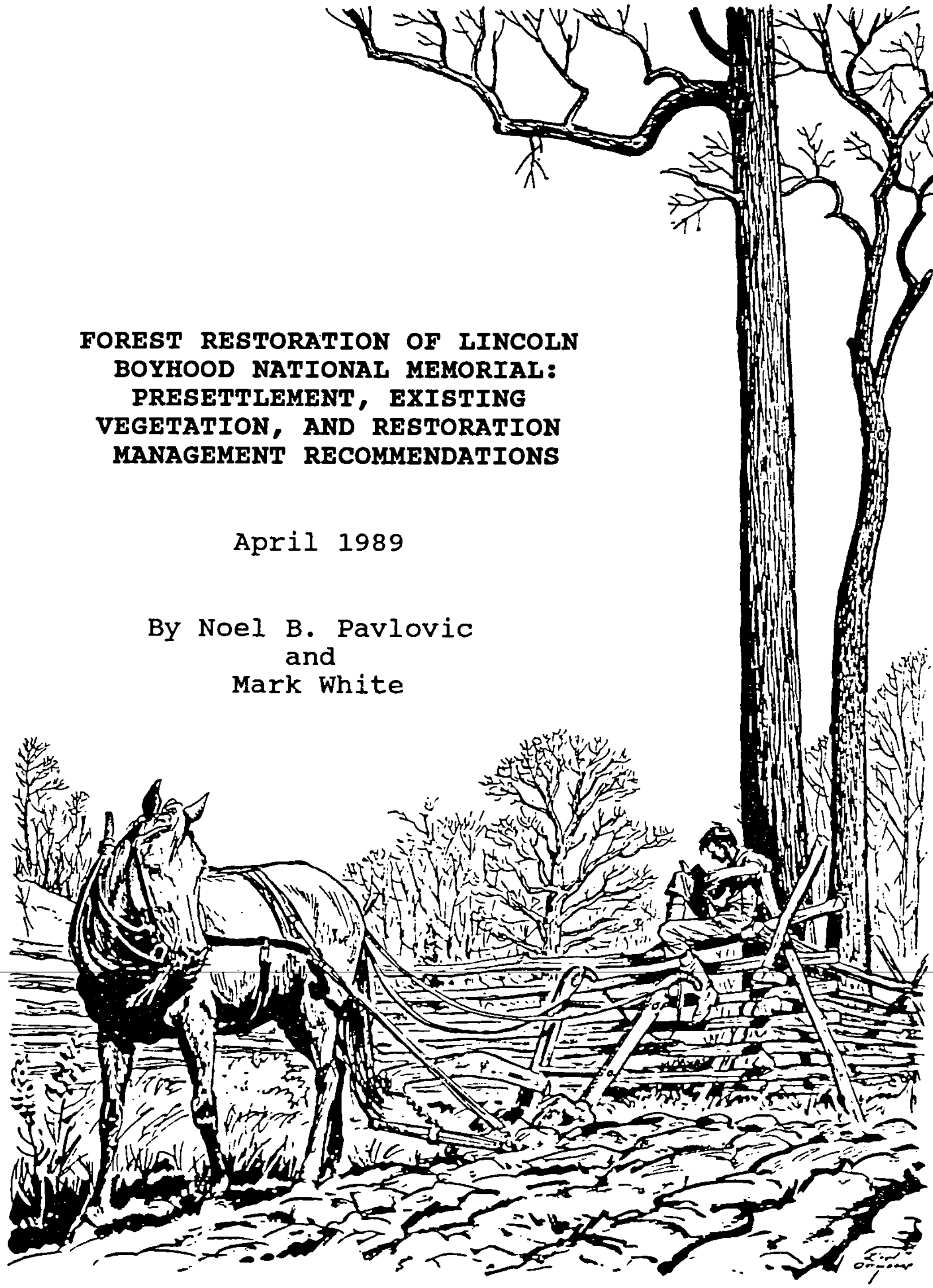

FOREST RESTORATION OF LINCOLN BOYHOOD NATIONAL MEMORIAL: PRESETTLEMENT, EXISTING VEGETATION, AND RESTORATION MANAGEMENT RECOMMENDATIONS[1]

April 1989

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[1] Cover artwork by Lloyd Ostendorf from **Abraham Lincoln: The Boy The Man**. 1962. Wagner Office Systems: Springfield, IL. p 39.

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ABSTRACT

A study was initiated in 1984 to recommend how to approximate the presettlement forest at Lincoln Boyhood National Memorial. The goals were to study the presettlement vegetation from the General Land Survey perspective, to characterize the current vegetation, and to recommend how to approximate the presettlement vegetation. Additionally, a ranking system was developed to assist in the prioritization of management activities.

General Land Survey records (1805) were examined for witness tree species composition relative to topographic position to obtain an impression of the presettlement forest. The records indicated an predominance of oak-hickory forest which was subdivided into upland, mesic and bottomland types.

Fifty-two stratified random 1/10th hectare plots were sampled throughout the park. All trees were identified and measured for dbh and shrub species were counted in a nested 1/20th hectare plot. Herbaceous frequency was quantified based on a systematic sample from 10 quadrats within each plot. Indirect gradient analysis and cluster analysis indicated a diverse type of communities bearing little relationship to topographic moisture gradient position. Consequently, the stands were classified relative to composition and past history and included bottomland and upland old fields, successional forest, upland old growth forest, mixed maple/tulip-tree forest (planted in the early 1900's) and abandoned homesites.

The old growth forest retained its canopy composition and structure, however past grazing (hogs) had nearly eliminated the characteristic spring ephemeral geophytic herbs. Only jack-in-the-pulpits and green dragon, both containing calcium oxalate (a deterrent to hogs) were common. Unlike the surrounding communities that were pastured in the 19th century, this stand lacked rank growth of Japanese honeysuckle. A remnant bottomland forest and xeric west facing successional forests were similar in composition to presumed presettlement stands. The majority of the other forest types failed to compare with natural communities due to the predominance of shade tolerant and fire intolerant mesic species (such as red and sugar maple), the absence of oaks and hickories, the lack of herbaceous cover, and the ubiquity of japanese honeysuckle.

Critical management issues that were identified included the abundance of Japanese honeysuckle, vegetation inertia in abandoned homesites caused by exotic perennial lawn grasses, absence of oaks and hickories in the majority of the planted forests, the invasion of sugar maple and to a lesser extent tulip-tree into the old growth forest and the low abundance or absence of spring ephemeral herbs.

Management experiments to eliminate Japanese honeysuckle demonstrated that efforts may be most successful under a forested canopy where prolific growth is absent. Use of glyphosate may

also eliminate the few herbs present in these anthropogenic communities, unless it is applied in the fall after herb die back. A nursery for herbaceous plants may be required to restore the ground cover. Glyphosate was shown to reduce the cover of exotic perennial grasses in old lawns and allow invasion of successional herbs. The herbicide fails to kill all of the grasses but at least a quasi natural successional process has been initiated.

Oak trees that were planted in the old field showed deer browse, which may be why old field succession has been so slow. During the final sampling, seedlings of shingle oak were found and the presence of these was taken as a positive sign for establishment of large seeded tree species.

Restoration priorities were based on a quasi quantitative numerical ranking system divided into the following categories: ecological significance, historical significance, relative restoration cost, urgency for and practicality of restoration. Although all categories were given equal weights, they could be weighted to give certain categories greater importance. Stands given high priority include the upland old growth forest and the bottomland forest.

Forest restoration to approximate the presettlement vegetation at Lincoln Boyhood National Memorial will require a long-term concerted effort of management. Restoration will require innovation, creativity, and monitoring. Failures may be expected. It is hoped that those persons attempting to achieve the vision of an approximate oak-hickory forest will not be discouraged by failures and set backs. Such results will hopefully contribute to our knowledge of how to restore communities.

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INTRODUCTION

A. The Problem

Lincoln Boyhood National Memorial was incorporated into the National Park Service in 1962, when much of the property was given to the federal government by the State of Indiana. The park was authorized by an Act of Congress to "preserve the site in the State of Indiana associated with the boyhood and family of Abraham Lincoln", "the original Tom Lincoln Farm", and "the nearby gravesite of Nancy Hanks Lincoln" (Public Law 87-407, 28 FR 8379). Appendix A summarizes, in chronological order, historical events of importance in the area of Lincoln Boyhood National Memorial.

In 1983 the Midwest Regional Chief Scientist requested that Norm Henderson and Noel Pavlovic at Indiana Dunes National Lakeshore conduct a preliminary investigation into the questions discussed below. Their most significant finding was the recognition of the old growth oak-hickory forest (Henderson and Pavlovic, 1984). Out of this work it was deemed necessary to conduct a more thorough study of the area.

The focus is on the lands excluding the Lincoln Living Historical Farm, the Nancy Hanks Lincoln Gravesite, the Allee and the Lincoln Memorial. The 1986 Statement for Management for the Lincoln Boyhood National Memorial states "the woodlands of the park should eventually approximate the wilderness forest found by the pioneers in this area in the early 19th century" (Hellmers, 1984). This is based on a decision to manage these lands consistent with the intentions of the Indiana Lincoln Union and its predecessor organizations, on the lack of historical information about the Lincoln Homestead, and on the availability of vegetation data from the 1805 federal land survey. The purpose of this study was to: 1). determine the nature of the presettlement forest, 2). sample the existing vegetation to determine its divergence from the presettlement state, and 3). to recommend how to restore the memorial to an approximate presettlement condition.

B. The Setting

Lincoln Boyhood National Memorial (LBNM) is situated in northern Spencer County in southwestern Indiana (Fig. 1). It is approximately 200 acres in size and is divided into several parcels by existing roads. The "North Forty" is the 40 acres north of County Road B (CR B) which was the north half of Thomas Lincoln's land purchase. This area is currently a mixture of abandoned homesites, old fields, successional forests, and old roads. The east parcel (east of County Road A (CR A)), the southern 3/4ths of LBNM, is the largest and encompasses the Living Historical Farm, the Memorial Visitor Center, the CCC reforestation, the old growth forest, and the graveyard where Nancy Hanks Lincoln was buried. The west parcel includes the

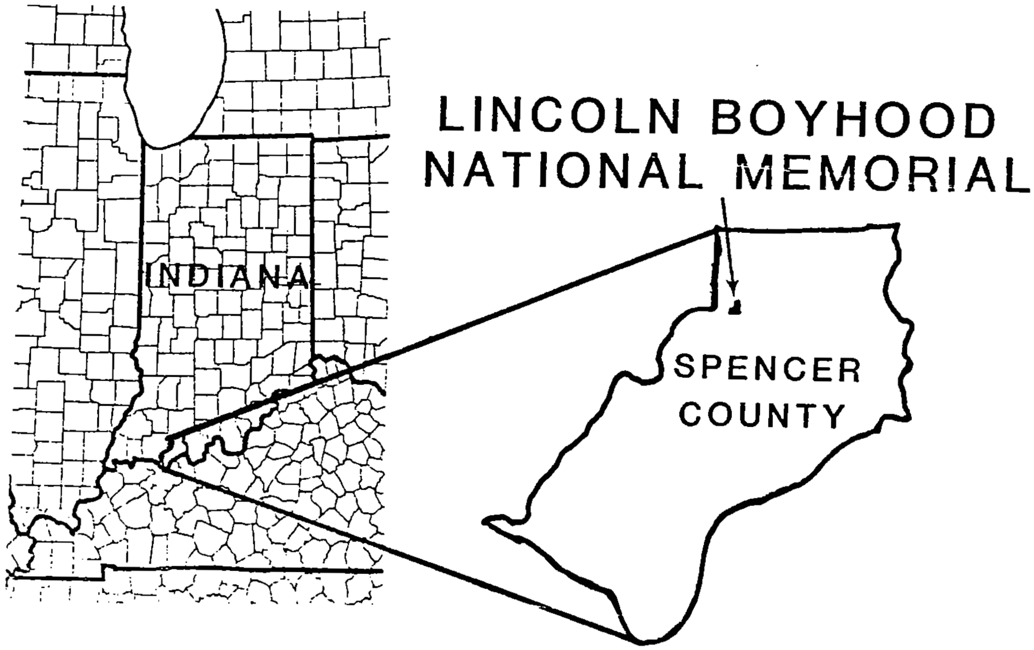

Figure 1. Location of Lincoln Boyhood National Memorial.

maintenance building, two Mission 66 homes, pasture land and various parcels of older second growth forests. South of LBNM is Lincoln State Park (LSP).

B1. **The Regional Climate**

Spencer County is moderate in climate with monthly average temperatures ranging from 1.3°C (34.5°F) in January to 26.0°C (78.8°F) in August at Tell City (USDA, 1973). The highest recorded temperature is 41°C (106°F) in August and the lowest is -25°C (-13°F) in January. Precipitation averages 44.75 inches per year with most of it being rain. Snowfall is confined from December to March (average January snowfall is 3.2 inches). The growing season is about 195 days (NPS, 1981).

B2. **The Physiognomy of the Landscape**

LBNM is in the Wabash Lowland physiographic province of southwestern Indiana in a transition to the Crawford Upland to the east (Schneider, 1966). Elevation ranges from about 415 feet to 512 feet above sea level, giving a relief of 100 feet (Fig. 2). The land above 450' is comprised of steep sloping hills dissected by shallow ravines, whereas below 450', the landscape is gently undulating. The highest sites in the memorial occur on the south portions with the lowest being within the "North Forty" acres. Most of the land surface has a northerly aspect.

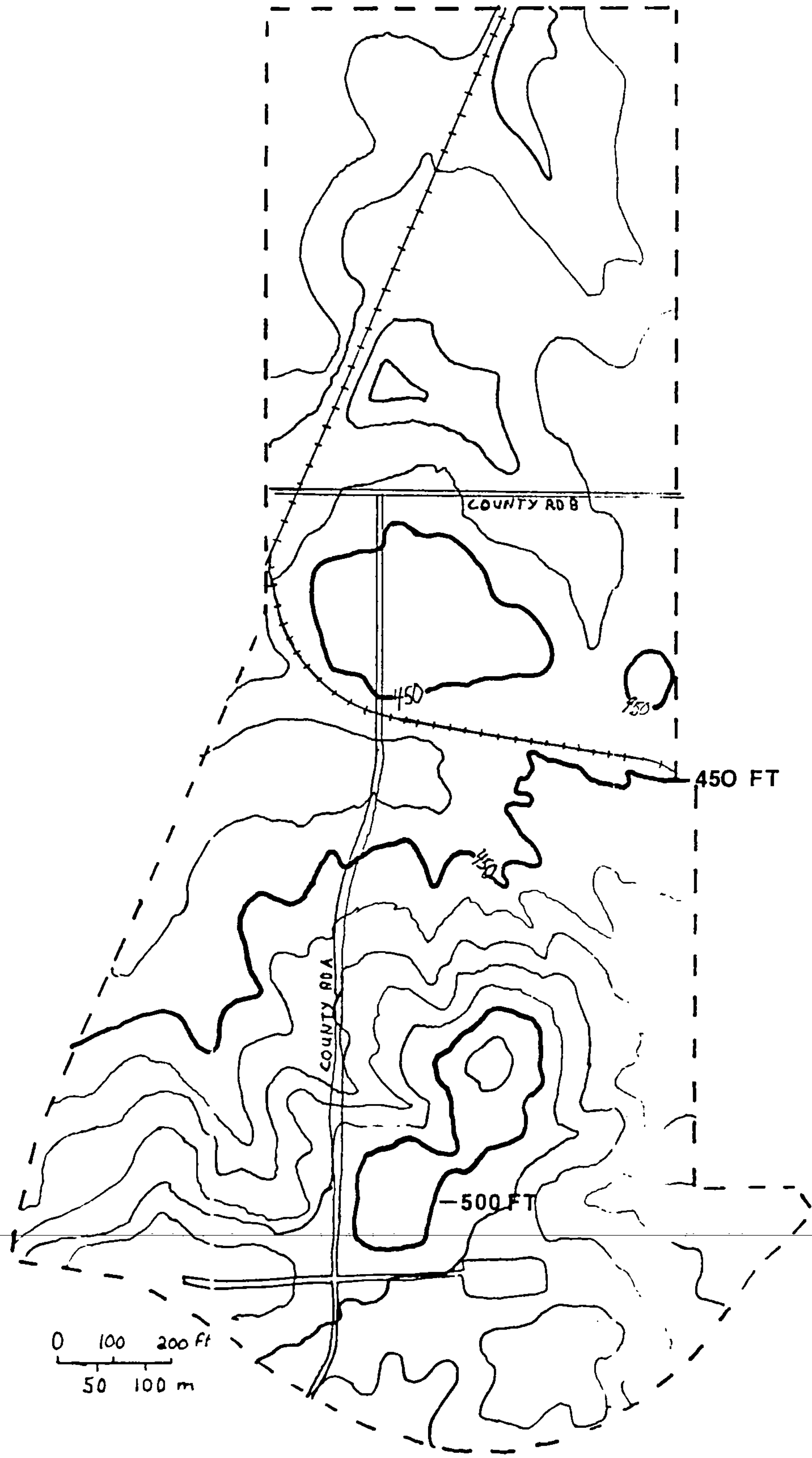

Figure 2. Topographic map of Lincoln Boyhood National Memorial. Contour interval is 10 feet.

B3. The Geological Setting

The land is underlain by Pennsylvanian age sandstones, shales, clay and thin coals of the Carbondale Group (State of Indiana, 1970). The lowland surficial material is alluvium derived from weathered sandstone and shale, whereas the upland is weathered loess derived from the Wabash River outwash in late Wisconsin time (Schneider, 1970). The area was unglaciated.

B4. The Soils

Soils in this part of Spencer County are mostly silt loams which are derived from various materials (Table 1). The five soil series can be generally arranged from driest to wettest on a moisture topographic gradient as follows: Zanesville, Wellston, Tilsit, Stendal, Bartle, and Atkins. The Atkins, Bartle, and Stendal soils are derived from alluvium, are acidic, poorly drained, and are subject to late winter or spring flooding or saturation due to a high water table. The Tilsit, Wellston, and Zanesville series of uplands developed from loess and weathered sandstone and shale, and are moderately well drained (USDA,1973). The Zanesville soil is the common soil of this area, especially on the topographic rises (Fig. 3).

Table 1. Characteristics of the soil series at Lincoln Boyhood National Memorial. Data are from the Spencer County soil survey (USDA,1973).

Series	Order	Subgroup	Parent Material	Texture
Atkins	Inceptisol	Fluventic Haplaquepts	alluvium	silt loam
Bartle	Alfisol	Aeric Fragiaqualfs	alluvium	silt loam
Stendal	Inceptisol	Aeric Fluventic Haplaquepts	alluvium	silt loam
Tilsit	Ultisol	Typic Fragiudults	loess	silt loam
Wellston	Alfisol	Ultic Hapludulfs	loess	silt loam
Zanesville	Ultisol	Typic Fragiudults	loess	silt loam

Series	Drainage	Horizons	Woodland Type
Atkins	poor		11-LIST,QUPA,ACRU,FRAM,PLOC,LITU*
Bartle	poor	fragipan	5-LIST,QUPA,ACRU,PLOC,BENI
Stendal	poor		13-LIST,QUPA,ACRU,PLOC,PODE
Tilsit	mod.well	fragipan	9-QUAL,QUVE,CASP,FRAM,LITU
Wellston	well		10-QUAL,QUVE,QURU,CASP,LITU,FAGR
Zanesville	well	fragipan	9-QUAL,QUVE,CASP,FRAM,LITU

* The species are: LIST-sweet gum, QUPA-pin oak, ACRU-red maple FRAM-white ash, PLOC-sycamore, LITU-tulip-tree, BENI-river birch, PODE-cottonwood, QUAL-white oak, QUVE-black oak, CASP-hickory, QURU-red oak, FAGR-beech.

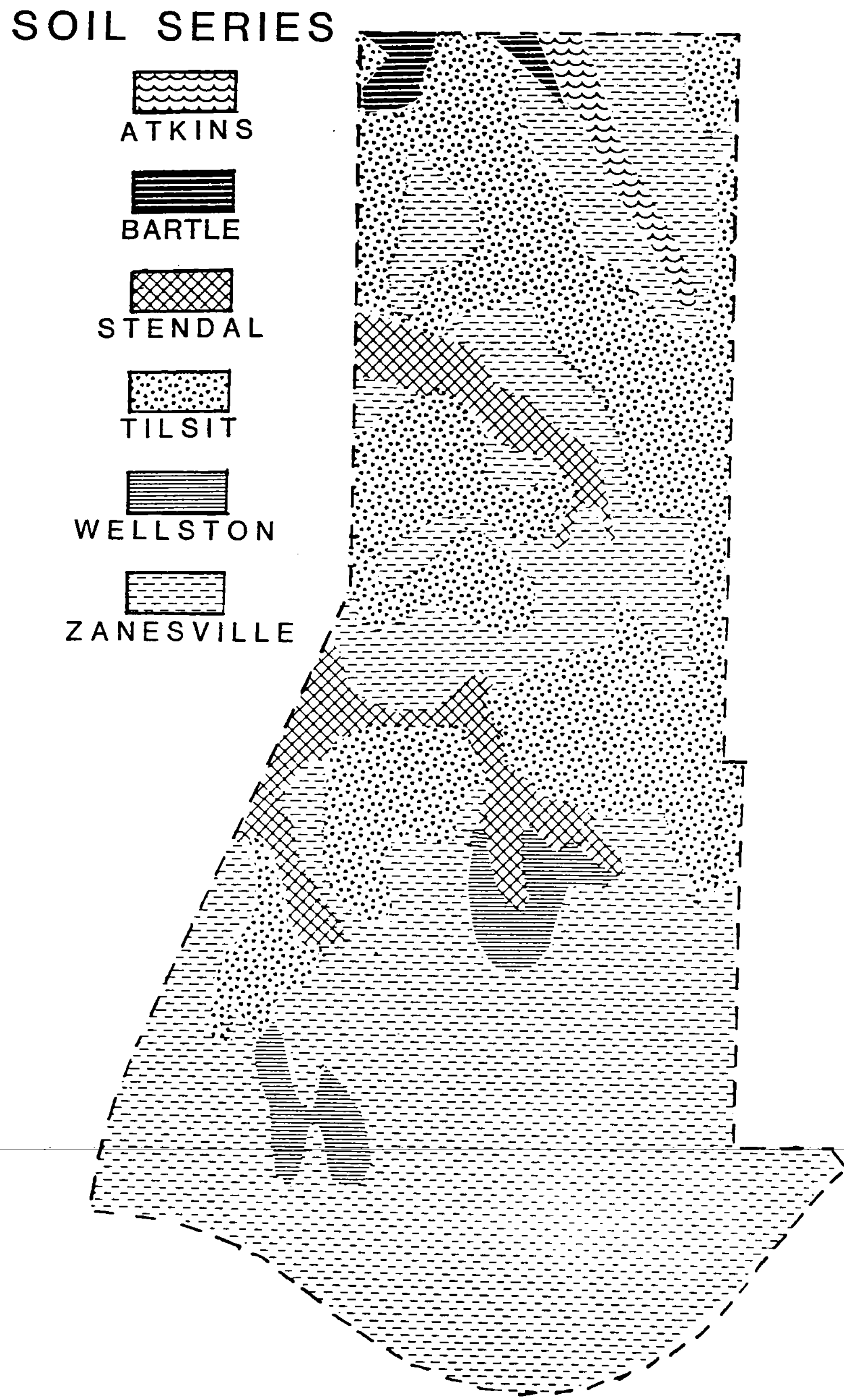

Figure 3. Soil series of Lincoln Boyhood National Memorial.

METHODS

A. The Presettlement Vegetation

General Land Office Township Survey Notes from 1805 (on microfilm) and copies of the township plat maps were examined for information concerning witness trees. The species of witness tree, its distance from the section corner or half section corner, and its azimuth from the corner were tallied. Any accompanying notes concerning soils, trees or understory were recorded. Also documents concerning early visitors' observations were examined for pertinent information. Tree elevations in the landscape were estimated by locating witness trees on 7.5 minute topographic maps. Other information about the soils and vegetation of the area was examined for clues about the presettlement vegetation.

B. The Current Vegetation

A baseline transect was set up (Fig. 4) along the north side of CR B which divides the "North Forty" from the southern 2/3 of the park. The east end was determined to be the imaginary intersection point between the north side of CR B and the line along the western ditch of the north south running road. The width of the park along CR B was measured and divided into five equal portions within which transect points were located using a random numbers table. Four transects were established. (The north-south running transects were at 53, 123, 226, and 283 m. west of the east end.) Galvanized conduit stakes mark the transects on the north side of the road except for the transect at 226 m. which is staked on the south side of the road. Along the north part of the transects, plots were located randomly within 100 m units which resulted in stratified random sampling. In the south 2/3rds of the transects, plots were randomly located in 150 m units since the vegetation pattern there was more uniform and less complex. One plot, in the bottomland forest remnant was subjectively located. Three plots were established in an undisturbed LSP upland hardwood forest southwest of LBNM, to serve as spatial disturbance controls.

Each plot is marked by a conduit stake. In the 7.98 m. radius circular plots, all trees and saplings >2.5 cm. d.b.h. were tallied (Appendix E, Fig. 1). The largest trees in the plot were cored to obtain minimum stand ages for the sites. Within a 5.64 m. radius circular plot, all shrubs >1 m. tall or <2.5 cm. d.b.h. were tallied. A total of ten 1 X 0.5 m herb-aceous plots were positioned, as illustrated in Appendix E (Fig. 1) to record the presence and frequency (from the 10 replicates) of the herbaceous species. Japanese honeysuckle (*Lonicera japonica* Thunb.) and tree seedlings were included in this strata. Finally soil samples were taken from each plot with a 2.54 cm diameter corer to a depth of 10 cm were taken. Chemical analyses of the soils were performed by A. & L. Agricultural Labs on a

Sampling intensity 1 acre

50pt/1200 acres

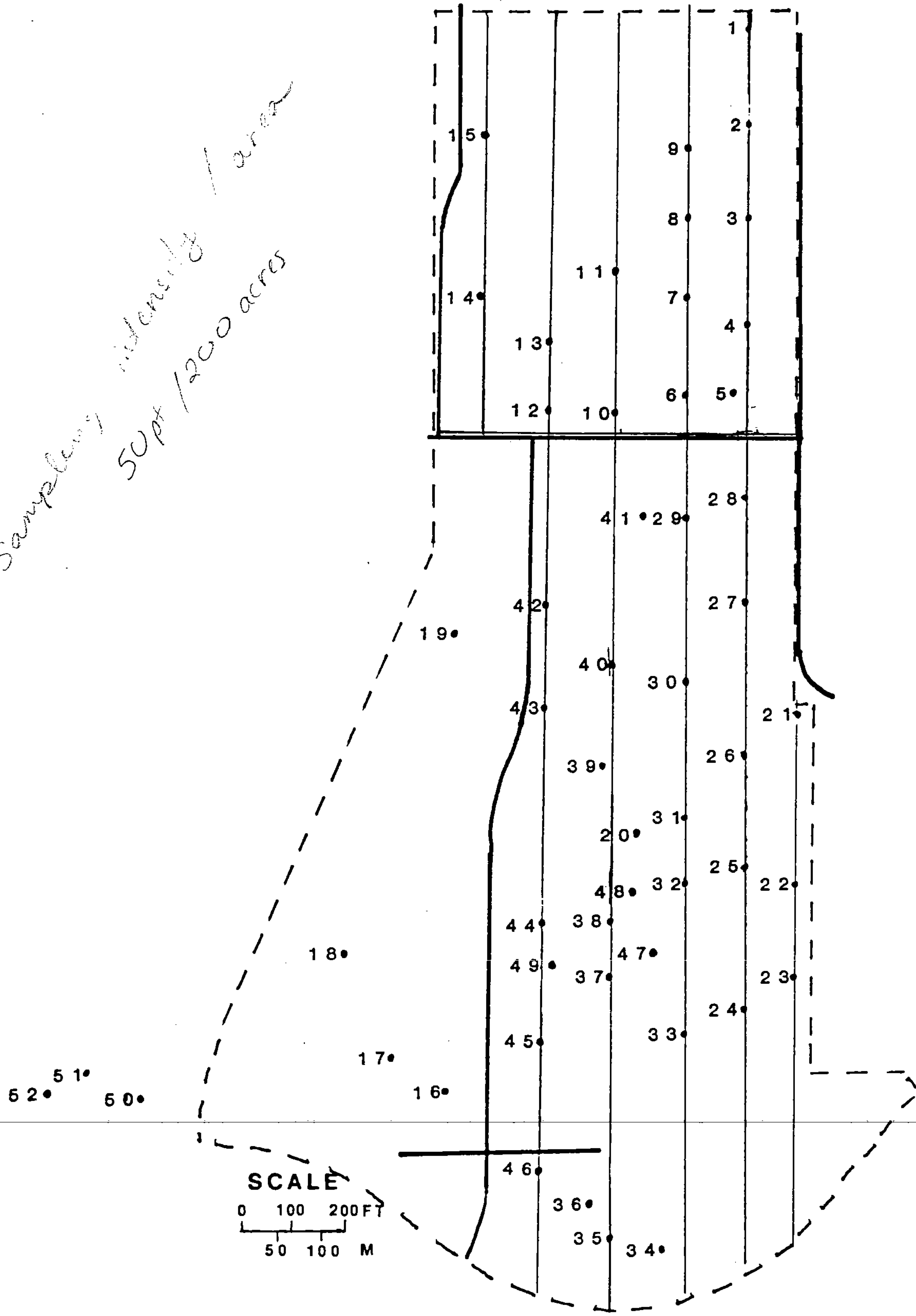

Figure 4. Map of the permanent plot locations at Lincoln Boyhood National Memorial. Quadrats are identified by numbers. Quadrats outside the boundary are located in an undisturbed oak-hickory forest in Lincoln State Park.

volume basis. Plant nomenclature follows Fernald (1970). Tree data was analyzed using average linkage cluster analysis and summarized with descriptive statistics. The herbaceous layer was summarized by indirect gradient analysis using detrended correspondence analysis.

C. The Management Experiments

Sampling the extant vegetation revealed several exotic plant species that are affecting succession at LBNM. These are Japanese honeysuckle and nonnative perennial grasses. Lack of oak reproduction in the old fields was a concern, so an experimental tree planting was performed in one of the old fields. Experiments were initiated in the spring of 1986 to address these problems as outlined below. By 1987 we observed natural tree invasion and realized that natural tree invasion is normally slow in old fields.

C1. Japanese honeysuckle

This exotic vine is undesirable in natural vegetation since it climbs over tree seedlings and sometimes into the trees (Evans, 1984), suppressing forest herbaceous cover as well. To restore LBNM to its near presettlement condition, attempts should be made to eliminate or reduce its impact on the native vegetation.

Numerous studies have investigated what treatments are best in eliminating Japanese honeysuckle. Evans (1984) in his review favored fire as a tool to eliminate honeysuckle. Stransky (1984) found burning preferable to mowing in eliminating this exotic. Such an option is not available in this study since the management plan fails to authorize prescribed fire for exotic removal, and such burns would have an adverse impact on some of the forest vegetation. Consequently, the following study was designed to examine how hand pulling and herbicide treatments affect the abundance of Japanese honeysuckle.

Two study sites were selected for experimental treatments to determine the most successful method of eliminating Japanese honeysuckle. One site was at the ecotone between an old field and young forest in the "North Forty" acres where Japanese honeysuckle is quite dense. The other area was between the Living Historical Farm and Harrison St. on the east boundary of LBNM and between CR B and the railroad tracks. This site is a young successional forest with nearly complete canopy closure.

At the old field site a complete randomized design was used, consisting of sixteen 2 by 2 m. plots (Appendix, E Fig. E4A) allocated to two blocks. The four treatments consisted of: 1). controls, 2). hand pulling of honeysuckle (June 4, 1986), 3). application of glyphosate (3 oz. Roundup/1000 sq. ft.) in the spring (June 13, 1986), and 4). an autumnal application of glyphosate (Sept. 29, 1986). Within these plots, two .5 by .5 m. subplots were randomly selected to sample the cover of the honeysuckle and the forbs prior and post treatment. These variables were used to assess treatment effects on the elimination of honeysuckle and potential recovery of the native vegetation.

At the forested successional site, a completely random design (Appendix E, Fig. 4B) was set up to examine the effect of vernal glyphosate application on the elimination of Japanese honeysuckle. Four 2 by 2 meter replicate plots per treatment were established and sampled for cover of honeysuckle and all other species using a meter square frame. Glyphosate application rate was the same as above.

In the old field site, only two plots were hand pulled due to time constraints and fatigue; consequently this treatment was eliminated from the analysis. The results from these experiments were analyzed using repeated measures analysis of variance (Gurevitch and Chester, 1986).

C2. **Nonnative perennial grasses**

Preliminary results from research at Indiana Dunes National Lakeshore suggest that treatments of glyphosate are effective in removing dense growth of introduced grasses found on old lawns and pastures. The following study was designed to examine the effectiveness of this herbicide in removing the nonnative grasses found at Lincoln Boyhood National Memorial.

Nine 3 by 3 m. plots in a 3 by 3 arrangement (Appendix E, Fig. E5) were set up in an old lawn area at the southwest corner of the southwest old field (Appendix E, Fig. E3) in the "North Forty" area of LBNM. Treatments in this randomized experiment included controls, herbicide only, and herbicide followed by raking to remove the dead biomass. Glyphosate was applied at a rate of 3 oz. per 1000 sq. ft. to eliminate the grass cover. Repeated measures analysis of variance was the statistical analysis method used.

C3. **Experimental tree planting**

In the southern, northeast facing old field ("North Forty"), black, white and pin oaks were planted on April 8, 1986. Saplings were planted randomly in a complete randomized block design (Appendix E, Fig. E3 & 6). Each block contained one replicate of each treatment and ran perpendicular to the slope. The four blocks were parallel to each other and in a line along the northeast facing slope. The 10 by 15 m plots were marked in the corners with galvanized electrical conduit and color coded as stated below. Treatments included a control (unpainted), tree planting only (yellow), mowing followed by tree planting (red), and tree planting with red maple removal (white). 15 saplings (6 to 8 inches) of each species were planted randomly in each plot. Saplings were obtained from the Indiana State Nursery at Vallonia. Trees were monitored in June and September of 1986 and 1987 to determine mortality. In June of 1987 all species of woody plants were tallied in each plot. Red maples were pulled on April 9, June 3, and September 1986. Red maple pulling was then discontinued.

RESULTS AND DISCUSSION

A. PRESETTLEMENT VEGETATION

A1. Results

Examination of the General Land Survey notes collected in 1805 by David Sanford and Arthur Henri indicate the vegetation was predominantly oak-hickory forest. Of the trees recorded within approximately 3 miles of the memorial, 29.6% were white oak (Quercus alba L.) and 21.9% were black oak (Quercus velutina Lam.) with the next most abundant species being hickory (Carya sp.) at 15.3% (Table 2, and Fig. 5). The data reveal by division into elevation classes, a topographic moisture gradient in species composition. For example, white oak, hickory, and dogwood (Cornus florida L.) were selected most frequently at higher elevations as witness trees, whereas black oak was equally selected at all elevation classes. Species such as black gum (Nyssa sylvatica Marsh.), elm, sugar maple (Acer saccharum Marsh.), silver maple (Acer saccharinum L.), and cottonwood (Populus deltoides Marsh.) were selected at lower and probably wetter elevations in the landscape. It is inferred that these trends reflect real changes in the vegetation even though the surveyors may have been biased in selecting certain species such as white oak as witness trees, due to the ease in blazing the trees (Bourdo, 1956). It is interesting to note how frequently black oak, a tree difficult to blaze, was selected as a witness tree, suggesting in many cases it was the only large tree species available and most likely to bear witness for a long time.

Spicebush ("spicewood", Lindera benzoin (L.) Blume) was an understory shrub commonly mentioned by the surveyors in upland flats and mesic coves. (Fig. 6) Bottomland areas were frequently mentioned as having oak timber with occasional mention of elm. Uplands often were noted as having oak and hickory.

A2. Discussion

The vegetation of Spencer County in the area of interest was probably a mosaic of dry and mesic oak-hickory forest on the uplands with interdigitating coves of mesic mixed hardwoods that graded into bottomland forests in the lower elevations with floodplain forests along streambanks. Potzger et al.(1956), from survey record studies of all of Indiana, found that oak-hickory forest was the presettlement vegetation of this area and that beech-maple grew to the north (Dubois County area) and to the east of the location of LBNM.

The probable presettlement vegetation pattern is mapped (Fig. 7) for LBNM around 1805. This map is similar to what would be obtained by using soil type and presettlement vegetation correlations from results presented by Lindsey et al. (1965).

Table 2. Summary of witness tree composition from 1805 land survey records within approximately 3 miles from Lincoln Boyhood National Memorial by elevation classes.

	# OF TREES					% OF TREES BY CLASS				
ELEVATION CLASSES	1[a]	2	3	4	ALL	1	2	3	4	ALL
SPECIES										
White oak [b]	4	38	37	10	89	14.8	26.8	32.7	52.6	29.6
Black oak	6	33	23	4	66	22.2	23.2	20.4	21.1	21.9
Hickory	1	19	25	1	46	3.7	13.4	22.1	5.2	15.3
Dogwood		7	24	4	35		4.9	21.2	21.1	11.6
Black gum	1	15	1		17	3.7	10.6	0.9		5.6
Elm	5	7			12	18.5	4.9			4.0
Maple	2	8			10	7.4	5.6			3.3
Cherry		5	1		6		3.5	0.9		2.0
Ash	1	2			3	3.7	1.4			1.0
Black jack oak		3			3		2.1			1.0
Sweet gum	3				3	11.1				1.0
Cottonwood	1	1			2	3.7	0.7			0.7
Mulberry		2			2		1.4			0.7
Soft maple	2				2	7.4				0.7
Apple		1			1		0.7			0.3
Honey locust	1				1	3.7				0.3
Red oak			1		1			0.9		0.3
Walnut			1		1			0.9		0.3
Total trees	27	141	113	19	300					

[a] Elevation classes are: 1 is ≤ 400'; 2 is > 400' and ≤ 450'; 3 is > 450' and ≤ 500'; and 4 is > 500'.

[b] White oak=*Quercus alba* L., Black oak=*Quercus velutina* Lam., Hickory=*Carya* spp., Dogwood=*Cornus florida* L., Black gum=*Nyssa sylvatica* Marsh., Elm=*Ulmus rubra* Muhl. or *americana* L., Maple=*Acer rubrum* L., Cherry=*Prunus serotina* Ehrh., Ash=*Fraxinus* sp., Black jack oak=*Quercus marilandica* Muenchh., Sweetgum=*Liquidambar styraciflua* L., Cottonwood=*Populus deltoides* Marsh., Mulberry=*Morus rubra* L., Soft maple=*Acer saccharinum* L., Apple=*Pyrus* sp., Honey locust=*Gleditsia triocanthos* L., Red oak=*Quercus rubra* L., Walnut=*Juglans nigra* L.

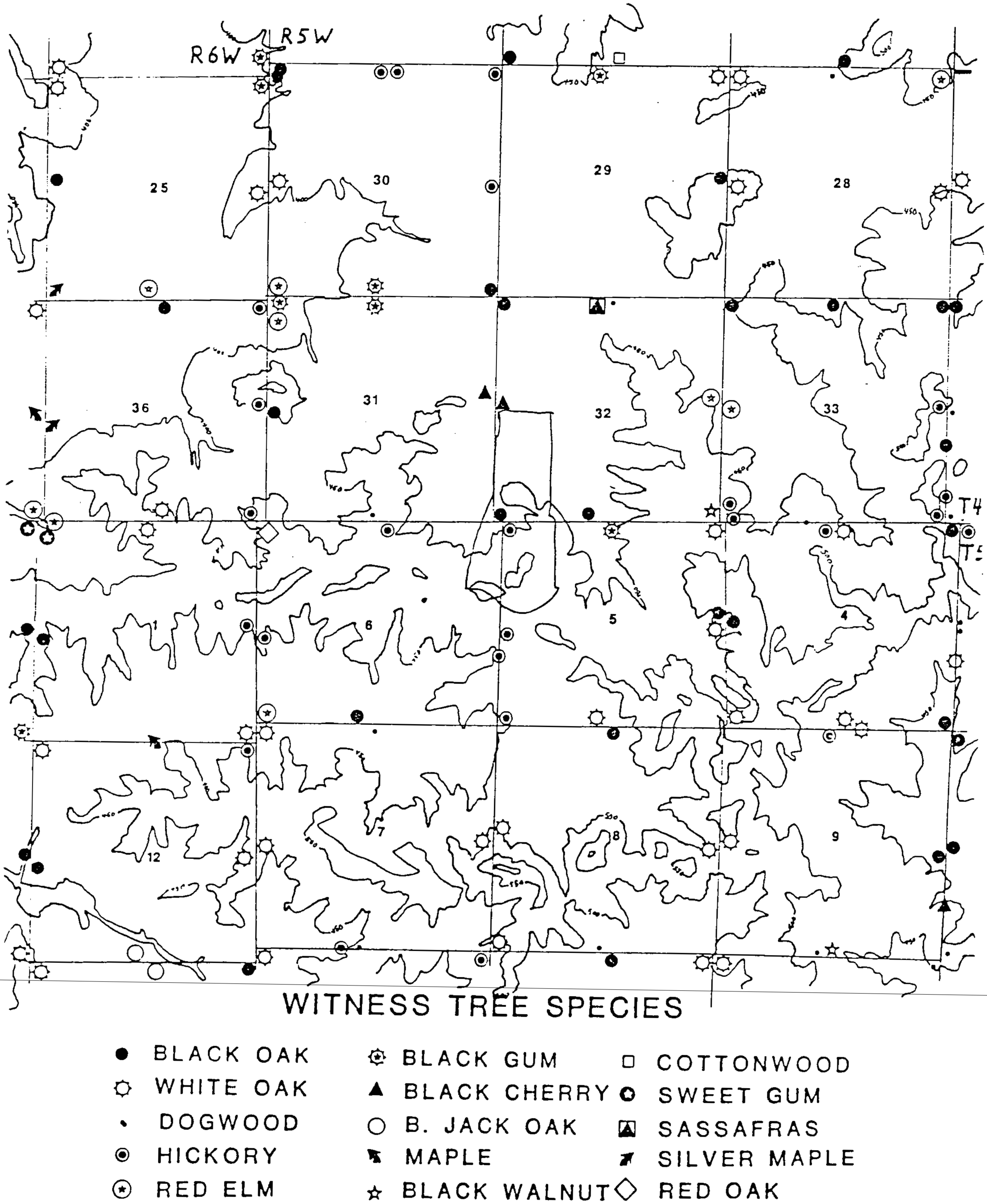

Figure 5. Map of witness trees surveyed in 1805 within approximately a three mile radius from Lincoln Boyhood National Memorial. Lines within the sections are the 400, 450, or 500 foot contour intervals. Each section is a square mile.

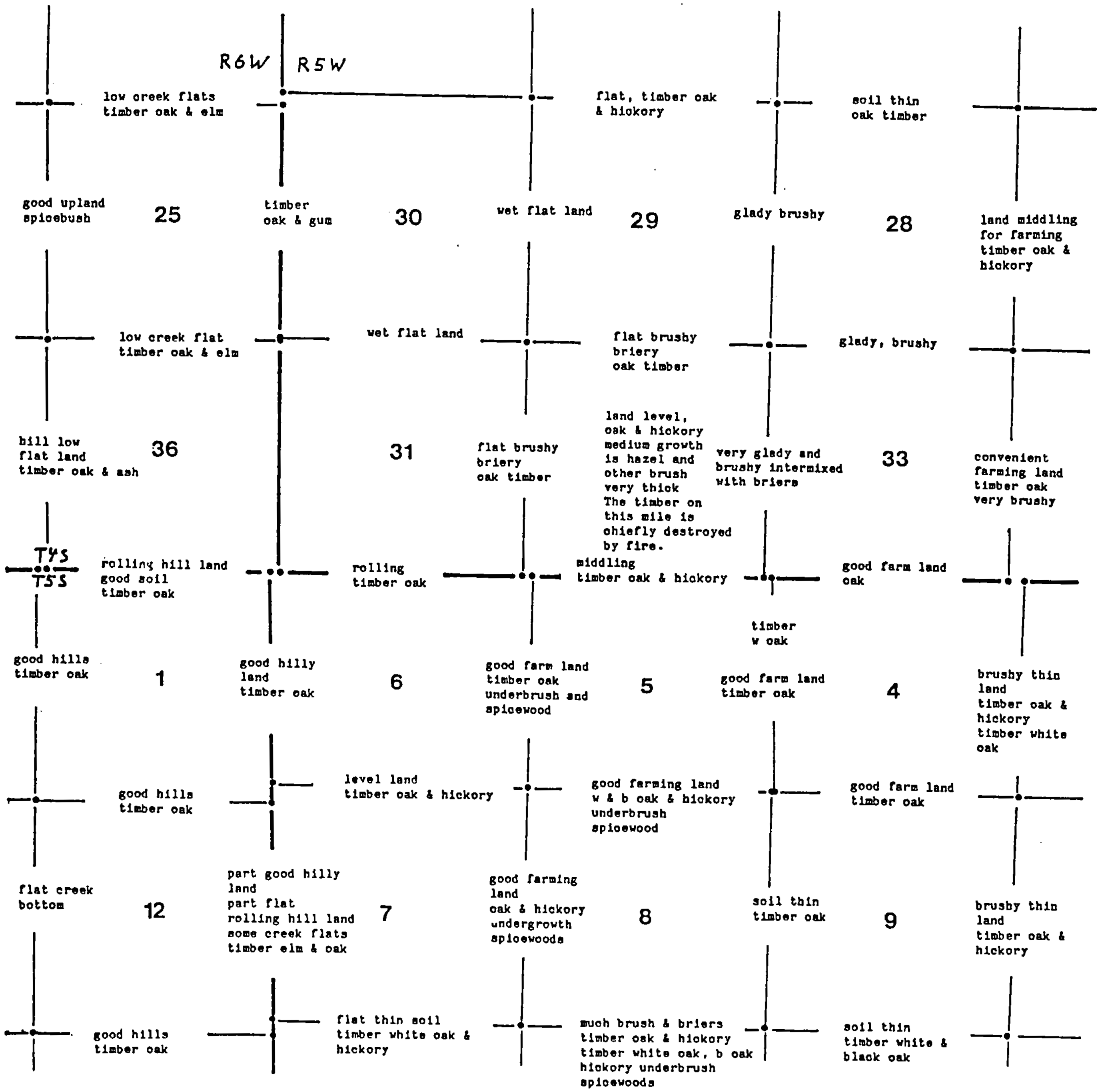

Figure 6. General Land surveyor's notes concerning the land quality and vegetation while surveying the section lines in 1805.

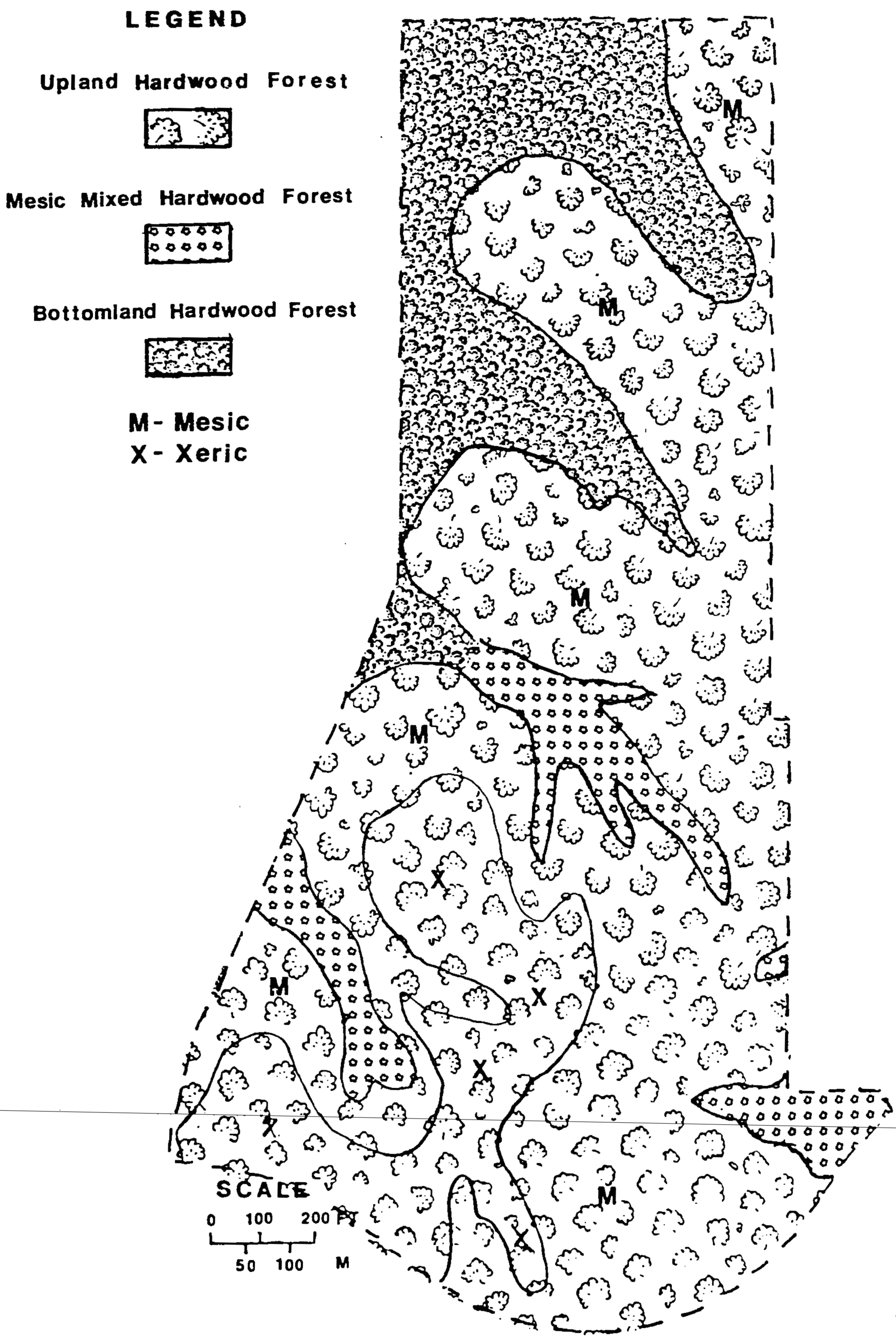

Figure 7. Presettlement vegetation of Lincoln Boyhood National Memorial. Map is based on land survey notes and on vegetation correlations with topography and soil type.

The only difference is that the Tilsit soil would be bottomland forest rather than beech-maple..

The upland forest would have been dominated by white and black oak, shagbark (Carya ovata (Mill.) K. Koch.) and pignut hickory (Carya glabra (Mill.) Sweet) with an occasional white ash (Fraxinus americana L.). Other occasional oaks would have been post (Quercus stellata Wang.) and chestnut (Quercus muehlenbergii Engelm.). An American basswood (Tilia americana L.) was also located by Henderson and Pavlovic (1984) in these woods. The understory would have been composed of winged elm (Ulmus alata Michx.) on the steeper westerly slopes which graded into dogwood and redbud (Cercis canadensis L.) with black haw (Viburnum prunifolium L.) towards more north and east facing slopes. Pawpaw (Asimina triloba (L.) Dunal) would have grown on the moister coves especially in canopy gaps. The upland forest (oak and hickory) and portions of the bottomland forest ("North Forty") probably were somewhat scrubby and savanna-like, due to the fire that the surveyors noted and shingle (Quercus imbricaria Michx.), black oak and hickories would have been common. Other small savanna like openings (barrens, Hutchinson 1984) possibly occurred on the westerly facing slopes of the upland hardwoods west of CR A. These were not mapped.

Anderson and Brown (1986) state that mesic forests were confined to areas of rugged topography which were protected from fires. This might explain the confining of hickory, which is susceptible to fire injury (Fowells 1965 and Fralish pers. comm.), to the uplands in this area of Spencer County (Table 2). Mixed hardwood forests in the mesic northerly facing coves were intermediate between the bottomland and upland forests and were protected from fires. These would have had white and black oak, black walnut (Juglans nigra L.), butternut (Juglans cinerea L.), bitternut (Carya cordiformis (Wang) K. Koch) and shagbark hickory, white ash, red maple (Acer rubrum L.), and perhaps a few sugar maples. Compelling evidence for the presence of beech (Fagus grandifolia Ehrh.) is lacking. Dogwood, black haw, pawpaw,and spicebush would have been common in the understory.

Sugar maple was probably rare in this west end of Spencer County even though Bearse (1967) implies that it was present. Most of his sources however, including Thomas (1952), Buley (1951) and Warren (1959), refer to sugar maple in the context of pioneer records from southern Indiana in general. Only in a letter from Elizabeth Crawford dated May 3, 1866, reprinted in Hertz (1938), is sugar maple mentioned as growing in Spencer County. Since no mention of this species is made in the survey records, sugar maple was probably more common in the east dissected portions of Spencer County.

Bottomland had mixtures of the following species: pin oak (Quercus palustris Muenchh.), bitternut hickory, red maple, red elm, and sweet gum (Liquidambar styraciflua L.). White oak would have been a frequent associate. Sycamore (Platanus occidentalis L.) and river birch (Betula nigra L.) occurred along the edges of streams with an occasional cottonwood.

B. CURRENT VEGETATION

B1. Results

The present vegetation of LBNM reflects previous land use history and differential levels of anthropogenic disturbance including farming, homesite construction, grazing, fire suppression, and selective timber removal. Thus a mosaic of communities differing in structural and compositional attributes has developed.

The lower elevation areas show the most recent impacts whereas upland sites have been disturbed less recently (Fig. 8). Old fields and homesites are found north of CR B and west of CR A. The bulk of bottomland successional forest is found north of CR B. Reforested mixed maple/tulip-tree forest, upland hardwood forest and upland successional forest occurs south of CR B and east of CR A. Red cedar dominated old field, mesic mixed hardwood forest and upland successional forest occur on the southwest dissected portion of the memorial. Comparisons between communities are tentative especially for those of small sample size since not all communities were sampled with the same effort.

A within groups average linkage cluster analysis (including the 1983 Henderson and Pavlovic data) revealed four canopy types (Fig. 9); 1. Red maple/sweet gum dominated stands, 2. Sugar maple/tulip-tree stands, 3. old growth oak hickory forest, and 4. a heterogeneous group of successional stands from all topographic positions. The last mentioned group contains upland and lowland successional and reforested stands which fail to fit within the other three stands. Since this compositional classification was unsatisfactory for such disturbed communities, a classification of the stands based on their location, their history and composition was used (as in Fig. 8) for the management component and vegetation descriptive sections of this report.

Plots at the left side of the herbaceous (frequency) gradient (Fig. 10) have a mesophytic forest understory, whereas, those at the low right have old field vegetation and those on the upper right are dominated by nonnative exotics of homesites (Fig. 10). Plots in the center have a low diversity of successional forest herbs. These gradients primarily are successional and are related to the disturbance history of LBNM. For example, plots 16, 17, 18, 50, 51 and 52 have a rich undisturbed vernal ephemeral flora, whereas the plots below and to the right of these in Figure 10A have some of the same vernal species but at much lower frequencies.

Soil Characteristics

The soil chemistry for most characteristics fails to demonstrate significant differences (Table 3). Organic matter content was consistently low, but the bottomland forest had the highest level. Soil phosphorus was highest in razed homesites

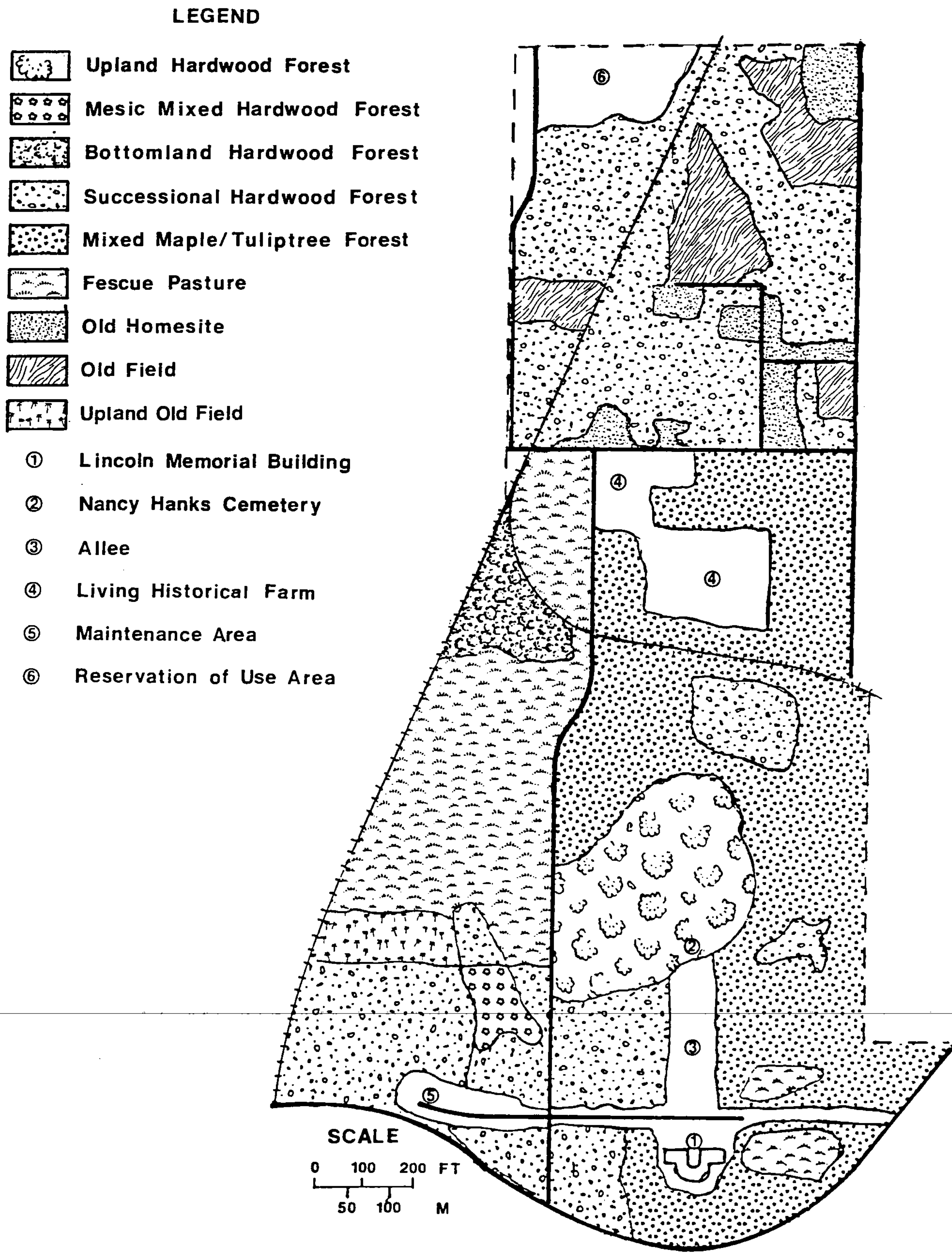

Figure 8. Current vegetation of Lincoln Boyhood National Memorial.

Figure 9. Dendrogram of within groups average linkage cluster analysis of tree vegetation based on the 1983 Henderson and Pavlovic data and on data from this study. The plots are listed in order from left to right as they appear below: Red maple/sweet gum- HP2-2, HP3-1, HP1-2, HP1-1, HP2-1, 4, 3, HP5-2, 13, 29, 36, 6; Sugar maple/tuliptree- 39, 43, 35, HPO3-3, HPO3-1, HPO3-2, 47, 51, 50, 52, HPO4-1, HPO2-1, 49, 38, 34, 45, 20, 44, 31, HPO4-3, 32, 37, HPO4-2, 33, 48; Mixed successional forest- 24, 27, 28, 21, 25, 30, 16, 9, 15, 26, 46, HP4-2, HP6-1, 40, 17, HP4-1, HP5-1, 19. HPO = Henderson-Pavlovic old growth upland hardwood forest plots.

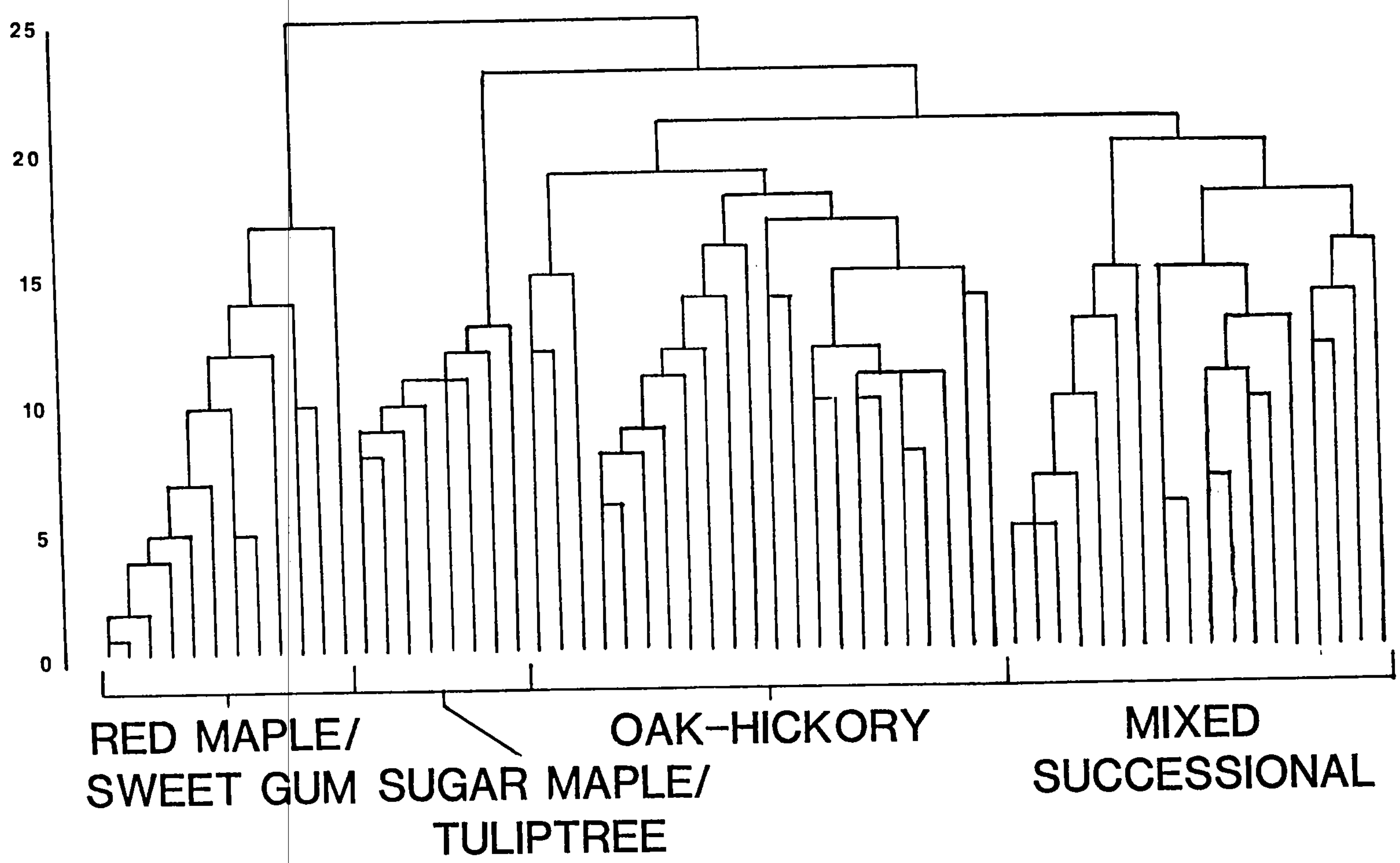

Figure 10. Detrended correspondence analysis of the herbaceous vegetation at LBNM. A. Quadrat ordination with vegetation units outlined. B. Species ordination with species named below, that occur in more than 10 half m^2 herb plots. The distance between quadrats reflects the similarity in species composition.

Acalrhom = *Acalypha rhomboidea*
Acerrubr = *Acer rubrum*
Acersacc = *Acer saccharum*
Alli sp = *Allium* sp.
Ambrarte = *Ambrosia artemissifolia*
Ambrbide = *Ambrosia bidentata*
Amphbrac = *Amphicarpa bracteata*
Andrvirg = *Andropogon virginicus*
Arisatro = *Arisaema atrorubens*
Aste sp = *Aster* sp
Bidearis = *Bidens aristosa*
Boehcyli = *Boehmeria cylindrica*
Botrbite = *Botrychium dissectum tenuifolium*
Botrvirg = *Botrychium virginianum*
Bromrace = *Bromus racemosus*
Campradi = *Campsis radicans*
Carycord = *Carya cordiformis*
Cassfasc = *Cassia fasiculata*
Cirs sp = *Cirsium* sp.
Clayvirg = *Claytonia virginica*
Cerccana = *Cercis canadensis*
Clemvirg = *Clematis virginiana*
Commcomm = *Commelina communis*
Cornflor = *Cornus florida*
Crypcana = *Cryptotaenia canadensis*
Dactglom = *Dactylis glomerata*
Dantspic = *Danthonia spicata*
Dauccaro = *Daucus carota*
Dentlaci = *Dentaria laciniata*
Desmpani = *Desmodium paniculatum*
Digisang = *Digitaria sanguinaria*
Diodtere = *Diodia teres*
Elymvirg = *Elymus virginicus*
Erig sp = *Erigeron* sp.
Erytamer = *Erythronium americanum*
Euonamer = *Euonymus americana*
Euphhyss = *Eupatorium hyssopifolium*
Euparugo = *Eupatorium rugosum*
Eupasero = *Eupatorium serotinum*
Festelat = *Festuca elatior*
Fraxamer = *Fraxinus americana*
Galiapar = *Galium aparine*
Galicirz = *Galium circaezens*
Galitrif = *Galium triflorum*
Geramacu = *Geranium maculatum*
Geum sp = *Geum* sp.
Glyc sp = *Glyceria* sp
Hypecana = *Hypericum canadensis*
Impacape = *Impatiens capensis*
Junc sp = *Juncus* sp.
Liguvulg = *Ligustrum vulgaris*
Lindbenz = *Lindera benzoin*
Liqustyr = *Liquidambar styraciflua*
Lirituli = *Liriodendron tulipifera*
Lobeinfl = *Lobelia inflata*
Lonijapo = *Lonicera japonica*
Moss = Moss
Oenobien = *Oenothera biennis*
Oxaleuro = *Oxalis europeana*
Oxalstri = *Oxalis stricta*
Panilanu = *Panicum lanuginosum*
Pani sp = *Panicum* sp.
Partquin = *Parthenocissus quinquefolia*
Phacbipi = *Phacelia bipinnatifida*
Phyrlept = *Phryma leptostachya*
Phytamer = *Phytolacca americana*
Pilepumi = *Pilea pumila*
Planmajo = *Plantago major*
Poa sp = *Poa* sp.
Podopelt = *Podophyllum peltatum*
Potesimp = *Potentilla simplex*
Prunsero = *Prunus serotina*
Prunvulg = *Prunella vulgaris*
Pycntenu = *Pycnanthemum tenuifolium*
Rhuscopa = *Rhus copallina*
Rhusradi = *Rhus radicans*
Rubu sp = *Rubus* sp.
Sanicana = *Sanicula canadensis*
Sassalbi = *Sassafras albidum*
Setageni = *Setaria geniculata*
Smil sp = *Smilax* sp.
Solacaro = *Solanum carolinense*
Soligran = *Solidago graminifolia*
Solinemo = *Solidago nemoralis*
Solimajo = *Solidago altissima*
Tovavirg = *Tovara virginiana*
Ulmurubr = *Ulmus rubra*
Vibudent = *Viburnum dentatum*
Vibuprun = *Viburnum prunifolium*
Vincmino = *Vinca minor*
Violstri = *Viola striata*
Violpapi = *Viola papilionacea*
Viti sp = *Vitis* sp

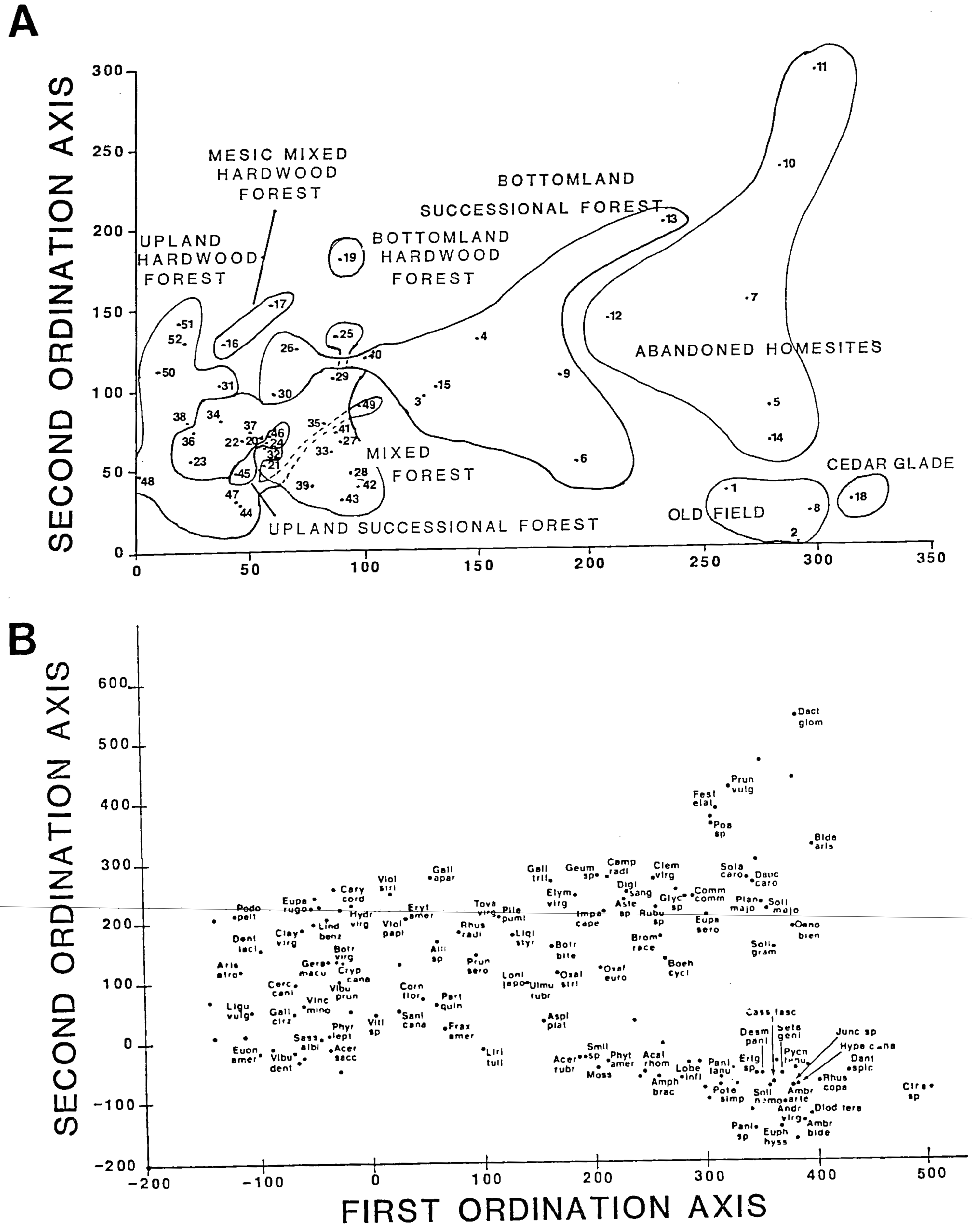
A
SECOND ORDINATION AXIS
MESIC MIXED HARDWOOD FOREST
BOTTOMLAND SUCCESSIONAL FOREST
UPLAND HARDWOOD FOREST
BOTTOMLAND HARDWOOD FOREST
ABANDONED HOMESITES
MIXED FOREST
CEDAR GLADE
OLD FIELD
UPLAND SUCCESSIONAL FOREST
B
SECOND ORDINATION AXIS
FIRST ORDINATION AXIS

Table 3. Soil characteristics by vegetation type. Soils were collected in August 1985.

	LOWF*IELD	UPOFIELD	ABANHOME	BOTTSUCF	BOTTOMFO	MIXPLANT	UPSUCCFO	MESIHARD	UPHARDFO	SPUPHRDF
Sample size:	3	1	6	9	1	15	3	2	9	3
Organic matter (ppm)	2.5	2.7	4.1	3.5	5.4	3.4	4.0	3.4	3.1	2.8
Phosphorus (ppm)	6.0	3.0	40.2	21.3	6.0	10.3	13.0	10.7	10.3	10.7
Potassium (ppm)	96	80	156	88	78	86	101	92	80	81
Magnesium (ppm)	122	100	106	101	215	92	182	202	67	65
Calcium (ppm)	900	450	1600	806	1950	726	1100	850	667	633
Ph	5.0	4.8	5.9	5.1	5.8	5.1	5.5	5.1	5.2	4.9
Cation Exchange Cap.	10.6	11.7	10.7	10.0	12.9	9.1	9.7	11.0	8.9	9.1
% Potassium	2.3	1.8	3.9	2.3	1.5	2.5	2.7	2.3	2.3	2.3
% Magnesium	9.5	7.1	8.2	8.6	13.8	8.7	15.7	13.5	6.2	6.0
% Calcium	42.9	19.2	74.3	41.0	75.3	41.3	56.8	37.6	38.2	35.4
% Hydrogen	45.3	71.9	13.6	48.2	9.4	47.4	24.8	46.6	53.3	56.3

* The plant communities are as follows: LOWFIELD - old field, UPOFIELD - upland old field, ABANHOME - abandoned homesite, BOTTSUCF - bottomland successional forest, BOTTOMFO - bottomland hardwood forest, MIXPLANT - mixed maple/tulip-tree forest, UPSUCCFO - upland successional forest, MESIHARD - mesic mixed hardwood forest, UPHARDFO - upland hardwood forest, SPUPHRDF - Lincoln State Park upland hardwood forest.

and bottomland successional forest. This phosphorus enrichment may reflect past land use. Potassium, calcium, and pH were higher in the abandoned homesites and bottomland forest than the background levels in the other communities. Total cation exchange capacity was fairly uniform across the communities, but proportions for each cation contributing to exchange capacity differed greatly.

Structural Features

The structure of lowland and upland old fields, and razed homesites are similar in lacking or having minimum tree and sapling densities and basal areas; however they had the highest density of shrubs of any other communities sampled (Table 4).

Table 4. Structural features of the vegetation at LBNM. Density is number per hectare and basal area is m^2 per hectare.

	LOWF* IELD	UPOF IELD	ABAN HOME	BOTT SUCF	BOTT OMFO	MIXP LANT	UPSU CCFO	MESI HARD	UPHA RDFO	SPUP HRDF
Sample size:	3	1	6	9	1	15	3	2	9	3
Elevation (ft)	433	458	435	434	445	461	474	490	488	477
Stand age	-	-	-	26	45	50	57	43	93	79
max.	-	-	-	40	45	65	70	55	147	84
min.	-	-	-	12	45	11	48	30	40	72
Tree density	-	-	83	644	600	460	550	450	228	283
Tree basal area	-	-	1.53	17.94	61.31	28.23	32.75	26.14	39.36	31.09
Sapling density	-	200	367	900	350	463	767	675	589	650
Sapling basal area	-	0.33	0.47	2.64	0.72	1.12	1.84	1.42	1.91	1.17
Shrub density	1534	2600	1733	942	400	1277	900	1464	1452	1132

* The plant communities are as follows: LOWFIELD - old field, UPOFIELD - upland old field, ABANHOME - abandoned homesite, BOTTSUCF - bottomland successional forest, BOTTOMFO - bottomland hardwood forest, MIXPLANT - mixed maple/tulip-tree forest, UPSUCCFO - upland successional forest, MESIHARD - mesic mixed hardwood forest, UPHARDFO - upland hardwood forest, SPUPHRDF - Lincoln State Park upland hardwood forest.

Since these are early successional communities these structural characteristics are expected.

Of the forested communities, the mixed maple/tulip-tree, the mesic mixed hardwood, the upland successional and the upland hardwood forests all have comparable basal areas. The LBNM and LSP upland hardwood stands have lower densities of stems relative to the other stands which means the trees are bigger in dbh since the basal areas are equivalent. The mixed maple/tulip-tree community has the lowest sapling density of the four communities which is reflected in its open understory. Sapling basal areas are highest in the mesic mixed hardwood forest and the LBNM upland hardwood forest.

The bottomland successional forest and the bottomland forest have respectively lower and higher basal areas than the above mentioned forests and both have very high tree densities. The latter type may have extremely high basal area since it is represented by only one plot and may also reflect big tree bias (McClure and Menges, 1986).

Species Richness by Community

Trends in overstory, sapling and shrub richness were parallel across the communities (Table 5). The mixed maple/tulip-tree forest had the richest overstory and the

Table 5. Species richness of the vegetation at LBNM by vegetation strata and growth form.

	LOWF* IELD	UPOF IELD	ABAN HOME	BOTT SUCF	BOTT OMFO	MIXP LANT	UPSU CCFO	MESI HARD	UPHA RDFO	SPUP HRDF
Sample size:	3	1	6	9	1	15	3	2	9	3
Elevation (ft)	433	458	435	434	445	461	474	490	488	477
Trees	-	-	2	13	7	16	12	9	13	7
Saplings	1	3	9	18	2	18	7	8	4	6
Shrubs	5	7	9	10	3	16	9	5	15	4
Vines	-	-	1	-	-	-	-	-	-	-
Herbs	40	19	63	57	18	34	16	23	35	23
Tree seedlings	5	1	9	12	1	14	10	9	11	7
Shrubs	1	1	2	3	2	7	5	3	6	2
Vines	5	3	8	8	6	7	5	5	7	6
Annuals	9	3	11	7	2	4	-	2	3	2
Biennials	2	1	3	-	-	-	-	-	-	-
Perennials	29	15	49	45	11	23	11	16	19	14
Vernal Perennials	-	-	-	5	5	7	5	5	13	7
Ferns & Fern Allies	-	1	3	4	-	5	2	3	-	-
Exotic species	8	2	17	8	1	4	2	1	3	2

* The plant communities are as follows: LOWFIELD - old field, UPOFIELD - upland old field, ABANHOME - abandoned homesite, BOTTSUCF - bottomland successional forest, BOTTOMFO - bottomland hardwood forest, MIXPLANT - mixed maple/tulip-tree forest, UPSUCCFO - upland successional forest, MESIHARD - mesic mixed hardwood forest, UPHARDFO - upland hardwood forest, SPUPHRDF - Lincoln State Park upland hardwood forest.

bottomland successional forest, the upland successional forest and the LBNM upland hardwood forest had intermediate overstory richness. Interestingly the upland successional forest and the upland hardwood forest had reduced sapling diversity relative to the overstory; but the mixed maple/tulip-tree forest and the bottomland successional forest had increased sapling richness compared to the overstory. Vines (excluding Japanese honeysuckle) were only found in the razed homesite community.

Herb richness was highest in the razed homesites and in the bottomland successional forest. Most of the communities were intermediate in species richness and the upland old field and the upland successional communities showed the lowest richness. Tree seedling richness was fairly uniform in the forested communities except the bottomland forest which had only one seedling species. Annual herbs were richest in the early successional communities and biennials were only found in the nonforested communities. Perennial herbrichness was highest in the razed homesites and bottomland successional forest. Vernal perennials were richest in the LBNM upland hardwood forest followed by the LSP upland hardwood forest and the mixed maple/tulip-tree forest. Ferns and fern allies were richest in the bottomland successional forest and the mixed maple/tulip-tree forest.

Exotic Plants

Few exotic tree or shrub species were encountered. Those found included white pine (*Pinus strobus* L.), privet (*Ligustrum vulgare* L.), mock-orange (*Philadelphus coronarius* L.), and perhaps sugar maple. More exotic species were found in the herb layer of razed homesites (27% of the total species) than in any other community. The species found throughout LBNM was Japanese honeysuckle (Fig. 11). The data show that this species is ubiquitous and that it has hardly invaded the upland hardwood forest. Reconnaissance monitoring indicated that the species is most troublesome at forest edges and clearings but that it persists under a closed forest canopy.

Plant Community Descriptions

Old fields

Lowland old fields, razed homesites and upland old fields all have red maple as their dominant, but they are otherwise dissimilar. Old fields have a rich shrub layer of red maple, dogwood, ash, sweetgum, and eastern red cedar (*Juniperus virginiana* L.) (Table 6). Sycamore occurs in lower drainage zones. Low old fields are invaded by red maple and blackberry which develops into an impenetrable thicket. Tree seedlings include red maple, dogwood, ash, shingle oak and red elm. Other species in the herbaceous zone include Japanese honeysuckle, virginia creeper (*Parthenocissus quinquefolia* (L.) Planch.), poison ivy (*Rhus radicans* L.), winged sumac (*Rhus copallina* L.), blackberry (*Rubus* sp.), and greenbrier (*Smilax* sp.). Ragweed (*Ambrosia artemissifolia* L.), partridge pea (*Cassia fasciculata* Michx.), buttonweed (*Diodea teres* Walt.), hyssop-leaved boneset (Eupatorium hyssopifolium L.), a rush (*Juncus* sp.), panic grass (*Panicum lanuginosum* Ell.), tall goldenrod (*Solidago altissima*

Table. 6. Woody vegetation summary for the lowland old fields at Lincoln Boyhood National Memorial.

	OVERSTORY		UNDERSTORY		SHRUBS
	DEN	BA	DEN	BA	DEN
Acer rubrum L.			17	0.02	1067
Cornus florida L.					200
Fraxinus americana L.					167
Liquidambar styraciflua L.					67
Juniperus virginiana L.					33

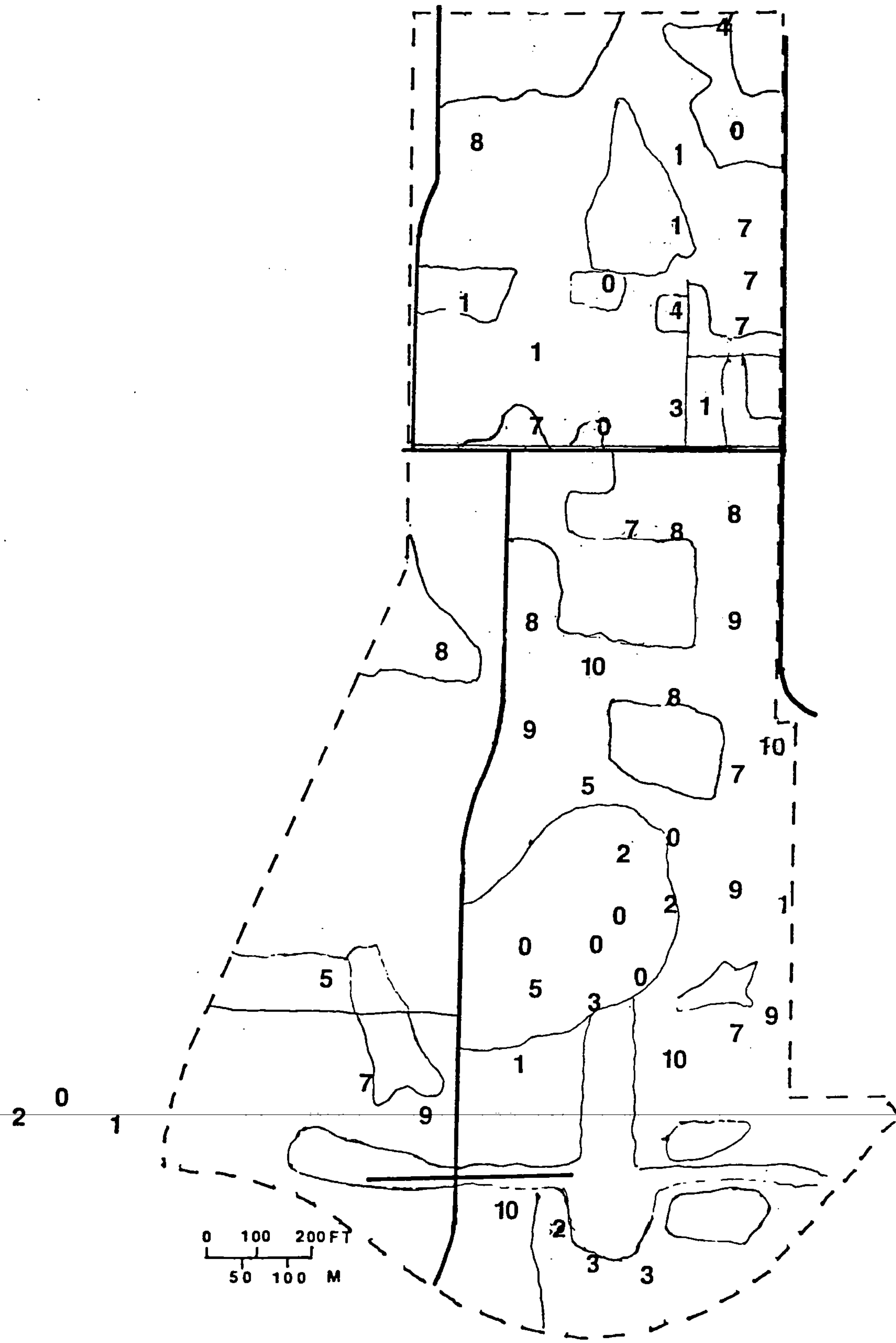

Figure 11. Frequency of Japanese honeysuckle at each quadrat based on ten subplots.

L.), and old-field goldenrod (S. nemoralis Ait.) dominate the herb layer.

Upland Old field

The upland old field is dominated by red maple, ash and dogwood saplings (Table 7). The shrub layer is richer with winged sumac, red maple, dogwood, ash, white pine (planted), red elm, and rock elm. Seedlings and vines include winged sumac, shingle oak, poison ivy and blackberry. The herbaceous layer shares some species with the old fields: tickseed sunflower (Bidens aristosa (Michx.) Britt.), partridge pea, Carex sp., panic grass, narrow leaved mountain mint (Pycnanthemum tenuifolium Schrad.), buttonweed and old field goldenrod.

Table 7. Upland old field shrub and tree vegetation at Lincoln Boyhood National Memorial.

	OVERSTORY		UNDERSTORY		SHRUBS
	DEN	BA	DEN	BA	DEN
Fraxinus americana L.			100	0.16	100
Acer rubrum L.			50	0.16	500
Cornus florida L.			50	0.05	400
Rhus copallina L.					1300
Pinus strobus L.					100
Ulmus alata Michx.					100
Ulmus rubra Muhl.					100

Abandoned Homesites

These are fairly open sites. Red maples and elms are the dominant trees, although some sites have other species such as American elm (Ulmus americana L.), Norway spruce (Picea abies(L.) Karst.) and white cedar (Thuja occidentalis L.) which have been planted (Table 8). The understory consists of a variety of mesic woody species, such as red elm, boxelder (Acer negundo L.), choke cherry (Prunus virginiana L.), black walnut (Juglans nigra L.), ash and winged sumac. Many of the same species predominate in the shrub layer as well. Black locust (Robinia pseudoacacia L.) grows as a young tree and has probably been introduced here.

Past homesite use has produced a mosaic of lawn and old field vegetation. Typical lawn herbs include fescue (Festuca elatior L.), brome (Bromus racemosus L.), orchard grass (Dactylis glomerata L.), bluegrass (Poa sp.), plantain (Plantago major L.), and foxtail grass (Setaria geniculata (Lam.) Beauv.). Common alien herbs are white sweet clover (Melilotus alba Desr.), wild carrot (Daucus carota L.), and Japanese honeysuckle. In grassy areas, old field goldenrod, tall goldenrod, partridge pea, and narrow leaved mountain mint are common.

Bottomland Successional Forest

These successional stands are floristically rich in the tree and sapling strata. On average they are dominated by sweet gum and red maple, but contain many species including dogwood, ash, persimmon, red elm, black cherry (Prunus serotina Ehrh.), silver maple (Acer saccharinum L.), sycamore, black locust, tulip-tree (Liriodendron tulipifera L.), and sassafras (Table 9). All of these species make up the understory, but sweet gum and dogwood predominate. Redbud, winged sumac, staghorn sumac (Rhus typhina L.) and southern arrowwood (Viburnum dentatum L.) are also found in the sapling and shrub layers. Successional stands on gentle ridges adjacent to the railroad are dominated by shingle, black oak and various hickory species.

Most frequent in the herb layer are Japanese honeysuckle, Virginia creeper, poison ivy, blackberry, Virginia wild rye (Elymus virginicus L.), red maple, and spotted touch me not (Impatiens capensis Meerb.). Along intermittent stream drainages grow false nettle (Boehmeria cylindrica (L.) Sw.) and white grass (Leersia virginica Willd.).

Bottomland Forest

Only a small portion of this mature community still exists at LBNM and this description is based on a single sample. The community is confined to flat, low sites where the soil becomes saturated in the late winter and spring. The overstory is dominated by pin oak with mesic species such as bitternut hickory, black walnut, red elm, red maple and American ash (Table 10). The understory is open, although this could be a result of past disturbance and litter dumping. The understory is composed of red elm, bitternut hickory saplings and spice bush.

The herbaceous cover of this community is luxurious. Frequent species include clearweed (Pilea pumila (L.) Gray), Japanese honeysuckle, Virginia wild rye, Geum sp., phacelia (Phacelia bipinnatida Michx.), pale violet (Viola striata Ait.), common blue violet, poison ivy and various tufted sedges.

Mixed Maple/Tulip-tree Forest

This community was created by reforestation in the 1920's and/or 30's. Prior to that most of this land was pasture. This community spans a broad elevational range so that it has a rich tree layer. In terms of the basal area and density, tulip-tree, sugar maple (Acer saccharum Marsh.), and red maple are dominant (Table 11). Species characteristic of low flat sites, include sweet gum, sourwood, and red elm. Species indicative of recent gap phase succession or disturbance include sassafras and eastern red cedar. White pine which has been planted grows at the southern end of LBNM in this community. The understory is

Table 8. Summary of woody vegetation for the razed homesites at Lincoln Boyhood National Memorial.

	OVERSTORY		UNDERSTORY		SHRUBS
	DEN	BA	DEN	BA	DEN
Acer rubrum L.	17	1.34			583
Ulmus rubra Muhl.	17	0.19	75	0.11	100
Dead	42	0.05			
Prunus virginiana L.			100	0.13	
Acer negundo L.			67	0.11	233
Fraxinus americana L.			42	0.05	167
Rhus copallina L.			33	0.04	100
Liquidambar styraciflua L.			25	0.02	67
Cornus florida L.			8	0.01	17
Alnus rugosa (Du Roi) Spreng.			8	0.01	
Juglans nigra L.			8	0.01	
Rubus sp.					283
Robinia pseudoacacia L.					33
Prunus serotina Ehrh.					67
Rhus typhina L.					83

Table 9. Woody vegetation summary for the bottomland successional forest at Lincoln Boyhood National Memorial.

	OVERSTORY		UNDERSTORY		SHRUBS
	DEN	BA	DEN	BA	DEN
Liquidambar styraciflua L.	161	5.69	517	1.13	122
Acer rubrum L.	194	5.35	11	0.80	444
Fraxinus americana L.	50	1.99	56	0.14	133
Prunus serotina Ehrh.	28	0.85	28	0.08	44
Robinia pseudoacacia L.	22	0.77	23	0.03	
Ulmus rubra Muhl.	33	0.76	56	0.71	33
Plantanus occidentalis L.	11	0.63	11	0.03	
Diospyros virginiana L.	31	0.50	23	0.02	
Acer saccharinum L.	23	0.51	33	0.04	
Dead	133	0.47			
Liriodendron tulipifera L.	11	0.39	11	0.46	11
Nyssa sylvatica Marsh.	11	0.22	17	0.06	
Cornus florida L.	61	0.12	189	0.43	100
Sassafras albidum (Nutt.) Nees	5	0.10	94	0.23	11
Rhus copallina L.			22	0.06	
Rhus typhina L.			17	0.01	
Cercis canadensis L.			28	0.05	33
Viburnum dentatum L.					11
Ulmus alata Michx.			17	0.09	
Morus alba L.			11	0.02	

Table 10. Woody vegetation in the bottomland forest at Lincoln Boyhood National Memorial.

	OVERSTORY DEN	OVERSTORY BA	UNDERSTORY DEN	UNDERSTORY BA	SHRUBS DEN
Acer rubrum L.	50	1.67			
Quercus palustris Muenchh.	150	39.04			
Fraxinus americana L.	50	8.31			100
Juglans nigra L.	100	8.05			
Ulmus rubra Muhl.	100	2.03	200	0.76	
Carya cordiformis (Wang)	100	1.60	150	0.24	200
Viburnum sp.	50	0.61			
Lindera benzoin (L.) Blume					100
dead	100	4.90	100	0.17	

Table 11. Woody vegetation of the mixed hardwood forest at Lincoln Boyhood National Memorial.

	OVERSTORY DEN	OVERSTORY BA	UNDERSTORY DEN	UNDERSTORY BA	SHRUBS DEN
Liriodendron tulipifera L.	41	8.48	14	0.03	67
Acer saccharum Marsh.	154	7.83	18	0.08	247
Acer rubrum L.	50	4.98			7
Pinus strobus L.	9	1.42	9	0.02	
Liquidambar styraciflua L.	23	1.20	9	0.03	33
Robinia pseudoacacia L.	23	1.01			
Sassafras albidum (Nutt.) Nees	32	0.93	41	0.09	22
Quercus rubra L.	9	0.76			7
Juniperus virginiana L.	18	0.53			22
Cornus florida L.	32	0.37	336	0.75	260
Prunus serotina Ehrh.	5	0.34	13	0.03	7
Fraxinus americana L.	14	0.21	5	<0.01	153
Carpinus caroliniana Walt.	14	0.30	14	0.06	
Nyssa sylvatica Marsh.	5	0.12	9	0.02	
Ulmus alata Michx.	5	0.09	9	0.05	
Ulmus rubra Muhl.	5	0.03	9	0.01	7
dead	18	0.05			
Quercus alba L.			23	0.02	
Carya ovata (Mill.) K. Koch			18	0.07	
Cercis canadensis L.			5	0.01	
Viburnum prunifolium L.			5	<0.01	127
Ostrya virginiana (Mill.) K. Koch			5	0.02	
Betula nigra L.			5	0.03	
Tilia americana L.					7
Lindera benzoin (L.)Blume					283
Morus rubra L.					7
Staphylea trifoliata L.					21

overwhelmingly dogwood, but has a rich representation of "rare" mesophytic species for this area: hornbeam (Carpinus caroliniana Walt.), redbud, American hophornbeam (Ostrya virginiana (Mill.) K. Koch) , and blackhaw. Spice bush, dogwood, sugar maple, ash and blackhaw are dominant in the shrub layers. Persimmon (Diospyros virginiana L.) grows in all strata.

Species most frequent in the herb layer are red maple, Japanese honeysuckle, Virginia creeper, sugar maple, poison ivy, and sassafras. This community is depauperate in herbs! Species such as honewort, geranium (Geranium maculatum L.), common blue violet, and phacelia are found occasionally, but spring ephemerals such as cutleaf toothwort, spring beauty, and trout lily are very rare. Miterwort (Mitella diphylla L.) was only found in this community and only at one site.

Mesic Hardwood Forest

This community is confined to protected ravines and is dominated by American ash plus a wide variety of hardwoods including shingle oak, hickories, and mesic species such as black cherry, red elm, and persimmon (Table 12). Dogwood and elm dominate the sapling zone. Redbud and dogwood make this community colorful in the spring by dominating the shrub zone.

Not to be outmatched by the shrubs, this community has the best spring wildflower display at LBNM. The most frequent herbs include wild onion, white snakeroot, spring beauty, cut leaf toothwort, yellow trout lily and phacelia. This high ephemeral diversity probably reflects lower past soil disturbance.

Upland Successional Forest

Upland successional stands lack evidence of planting in the late 1920's; therefore these stands represent natural succession modified by seed dispersal from nearby introduced trees (tulip-trees). The overstory is dominated by tulip-tree, sassafras, red maple, and sweetgum which are all mid successional species (Table 13). Although absent from the random plots, eastern red cedar is often present. Black cherry and dogwood dominate the sapling layer and the latter species and American ash share the shrub stratum.

Red maple, dogwood, ash, Japanese honeysuckle, virginia creeper, and sassafras are the common woody species in the herbaceous layer. Herbs are again sparse, but include ebony spleenwort (Asplenium platyneuron (L.) Oakes), grape fern (Botrychium virginianum (L.) Sw.), honewort, sedges and black snakeroot (Sanicula canadensis L.). The most unusual species growing in these stands was broadleaf uniola (Uniola latifolia Michx.).

Table 12. Vegetation summary for the mesic hardwood forest at Lincoln Boyhood National Memorial.

	OVERSTORY		UNDERSTORY		SHRUBS
	DEN	BA	DEN	BA	DEN
Fraxinus americana L.	125	10.56	25	0.03	
Quercus imbricaria Michx.	25	4.58			
Carya ovalis (Wang.) Sarg.	50	3.62			
Carya ovata (Mill.) K. Koch.	50	2.64			
Ulmus rubra Muhl.	50	1.57	100	0.26	
Carya glabra (Mill.) Sweet	100	1.44	25	0.06	
Prunus serotina Ehrh.	25	1.11			
Diospyros virginiana L.	25	0.62	25	0.09	50
Sassafras albidum (Nutt.) Nees	5	0.10			
Cornus florida L.			400	0.73	200
Carya cordiformis (Wang) K. Koch			50	0.03	150
Viburnum prunifolium L.			25	0.09	50
Juglans nigra L.			25	0.14	
Cercis canadensis L.					450
Dead	25	0.01			

Table 13. Woody vegetation of the upland successional forest at Lincoln Boyhood National Memorial.

	OVERSTORY		UNDERSTORY		SHRUBS
	DEN	BA	DEN	BA	DEN
Liriodendron tulipifera L.	117	11.99			
Acer rubrum L.	33	5.12			
Liquidambar styraciflua L.	83	4.43			
Prunus serotina Ehrh.	50	2.99	133	0.23	33
Sassafras albidum (Nutt.)	100	2.58	50	0.32	
Fraxinus americana L.	17	1.06			267
Acer saccharum Marsh.	33	1.05	17	0.03	33
Cornus florida L.	50	1.02	500	1.04	800
Ulmus americana L.	17	0.96			
Quercus velutina Lam.	17	0.50			
Ulmus alata Michx.	17	0.30	17	0.11	
Pinus strobus L.	17	0.14			
Quercus rubra L.			33	0.02	
Carya glabra (Mill.) Sweet			17	0.09	100
Viburnum prunifolium L.					66
Ligustrum vulgare L.					66
Hypericum sp.					33
Diospyros virginiana L.					66

Upland Hardwood Forest

The upland hardwood forest is the oldest and most impressive feature at LBNM due to the size of the oak trees. The stand is dominated by black, white, and red oak with shagbark and pignut hickories, and black walnut and chinquapin oak being subdominant (Table 14). This old stand varies from being mesic on the northeast and east facing slopes to more xeric on the west facing slopes. Sugar maple is confined to north facing ravines. Past disturbances such as selective cutting may have created gaps where scattered eastern red cedars now grow, but now evidence of selective cutting was found. Sugar maple, dogwood, redbud and spice bush dominate the shrub layer. Sweet mock-orange (_Philadephus_ _coronarius_ L.) was planted when the west portion of the stand was a groomed park leading to the Nancy Hanks Lincoln gravesite.

Seedlings include red maple, redbud, Virginia creeper, ash, poison ivy and sassafras. Herbaceous frequency is very low, reflecting a past disturbance that failed to introduce Japanese honeysuckle. Nevertheless this community had the greatest number of spring ephemeral species of any LBNM community. Yellow fumewort _Corydalis_ _flavula_ (Raf.) DC. was found growing on north facing flanking ridge crests.

The LSP upland hardwood forest is similar to that of LBNM, but it is more mesic due to its protected topographic position. It is dominated by white oak and ash; black oak, red oak and shagbark hickory are subdominants. Dogwood and redbud dominate the sapling layer and redbud and pawpaw (_Asimina_ _triloba_ (L.) Dunal), a species lacking from LBNM, are the dominant shrubs. Pawpaw is most common in the canopy gaps. The LSP forest has a very rich spring ephemeral flora including spring beauty, trout lily, bloodroot, and prairie trillium.

B2. Discussion

Late successional and mature oak dominated stands sampled at LBNM and LSP show comparable basal areas (approx. 30 m^2/ha) and densities (approx. 1000 stems/ha) as similar areas elsewhere: McEnvoy el al. (1980), Schmelz and Lindsey (1965), Schmelz et al. (1975), McCune and Menges (1986), Anderson and Adams (1978).

Potzger and Freisner (1934) studied Mauntel Woods which was north of LBNM. Mauntel Woods was quite similar to the stand in LSP in that both are dominated by white oaks and other oaks and hickory. Other similarities include the dominance of dogwood in the understory and the absence of hornbeam (_Carpinus_ _caroliniana_) and hophornbeam. Similarly shagbark and shellbark were the most common hickories.

Notable was the absence of beech and sugar maple in successional stands and in the mature forest. Braun (1950) stated that west of the Crawford Upland, mixed mesophytic communities were rare and that beech and maple only occupied the most favorable situations. Bearss' (1967) references to sugar maple

Table 14. Woody vegetation of the upland hardwood forests at Lincoln Boyhood National Memorial and Lincoln State Park.

	LINCOLN BOYHOOD					LINCOLN STATE PARK				
	OVERSTORY		UNDERSTORY			OVERSTORY		UNDERSTORY		
			SAPLING		SHRUB			SAPLING		SHRUB
	DEN	BA	DEN	BA	DEN	DEN	BA	DEN	BA	DEN
Quercus velutina	67	20.54				17	3.80			
Quercus alba	39	6.20				100	17.16			
Quercus rubra	11	5.52				33	2.99			
Juglans nigra L.	11	1.57								
Acer saccharum	28	1.46			222					
Quercus muhlenbergii	6	1.09			11					
Carya glabra	11	1.00								
Carya cordiformis (Wang)	11	0.89			11					
Carya tomentosa	6	0.61								
Cercis canadensis L.	17	0.19			267			300	0.37	833
Ulmus rubra Muhl.	11	0.17						33	0.05	33
Fraxinus americana L.	8	0.06			67	50	3.00	33	0.14	
Sassafras albidum (Nutt.)	6	0.06			33			17	0.11	33
Juniperus virginiana L.			139	0.55						
Nyssa sylvatica			17	0.08						
Cornus florida L.			39	0.06	155			200	0.43	
Prunus serotina Ehrh.			11	0.05	111	17	1.18			
Carya ovata						50	2.66			
Celtis occidentalis						17	0.30			
Lindera benzoin (L.) Blume					188					
Acer negundo L.					11					
Amelanchier sp.					22					
Diospyros virginiana L.					11					
Ulmus alata Michx.					44			50	0.07	
Philadelphus coronaria L.					288					
Ligustrum vulgare L.					11					
Asimina triloba										233

at LBNM are based on general statements about the vegetation of southern Indiana, that fail to recognize the spatial heterogeneity in the vegetation from east to west. He also quotes contemporary (1800's) figures of the quantities and costs of sugar maple and then matter of factly states "The Lincolns undoubtedly engaged in this trade.", without critically examining the probability that the trees occurred locally.

Tulip-tree is confined to successional and reforested stands. It was absent from all of the old forest remnants sampled and since it was not mentioned in the survey records, it was probably absent from LBNM at presettlement times. This species was probably introduced in the late 1800's. The allee planting was probably the source for this species in the upland successional forests.

Potzger and Freisner (1934) noted the lack of herbaceous understory and that poison ivy was most common just as it is at LBNM. Early successional stands similarly had Pycnanthemum flexuosum, Solidago nemoralis, and Lespedeza hirta as herbaceous dominants and persimmon, Eastern red cedar, sassafras, and sweetgum as woody invaders. Post, shingle, and blackjack oak were most common in early successional stands at Mauntel Woods.

C. THE MANAGEMENT EXPERIMENTS

This section presents the results of the experiments to eliminate the exotic plant species from Lincoln Boyhood National Memorial and to introduce oak seedlings into an old field.

C1. Results

Japanese honeysuckle

Cover of honeysuckle (Harrison St. experiment) declined greatly due to the application of the glyphosate relative to the controls (Fig. 12 and Table 15 and Appendix D, Table D1). The control plots differed significantly from the herbicided plots based on their totals over time (treatment-constant contrast) and on their trend curves in time (treatment- quadratic contrast). Although the herbaceous cover declined in the herbicide plots relative to the controls, the trends were insignificant probably due to the low initial herb cover and the small magnitude of the change. Controls differed significantly from treated plots in woody plant cover trends with time (treatment-quadratic contrast, controls concave downward and treated concave upward). The total number of species nearly halved relative to the controls. Thus the treatments caused a reduction in the cover of honeysuckle, woody plants, and herbs, and reduction in the number of species present per plot. No dramatic regeneration of herbs was observed. The dramatic decline in the values for the controls from June to September 1987 is likely caused by the drought during that summer which reduced the growth of both honeysuckle and herbs.

The old field honeysuckle removal experiment showed a variety of responses (Tables 16 and D2 and Fig. 13). Because only two replicates of the hand removal of honeysuckle were completed, these were eliminated from the statistical analysis. Nevertheless it is important to discuss the effect of hand removal since the results were very different from the other treatments. Vernal herbicide and hand removal were equally effective in reducing the honeysuckle cover. Autumnal herbicide, hand removal, and the controls showed parallel trends in herb cover over time with the hand removal plots having only a higher initial herbaceous cover. The autumnal 1986 dip in the vernal herbicide curve is due to the herbicide killing the above ground herbaceous cover. By the following spring, the herb cover was at normal levels. Hand pulling of honeysuckle caused dramatic

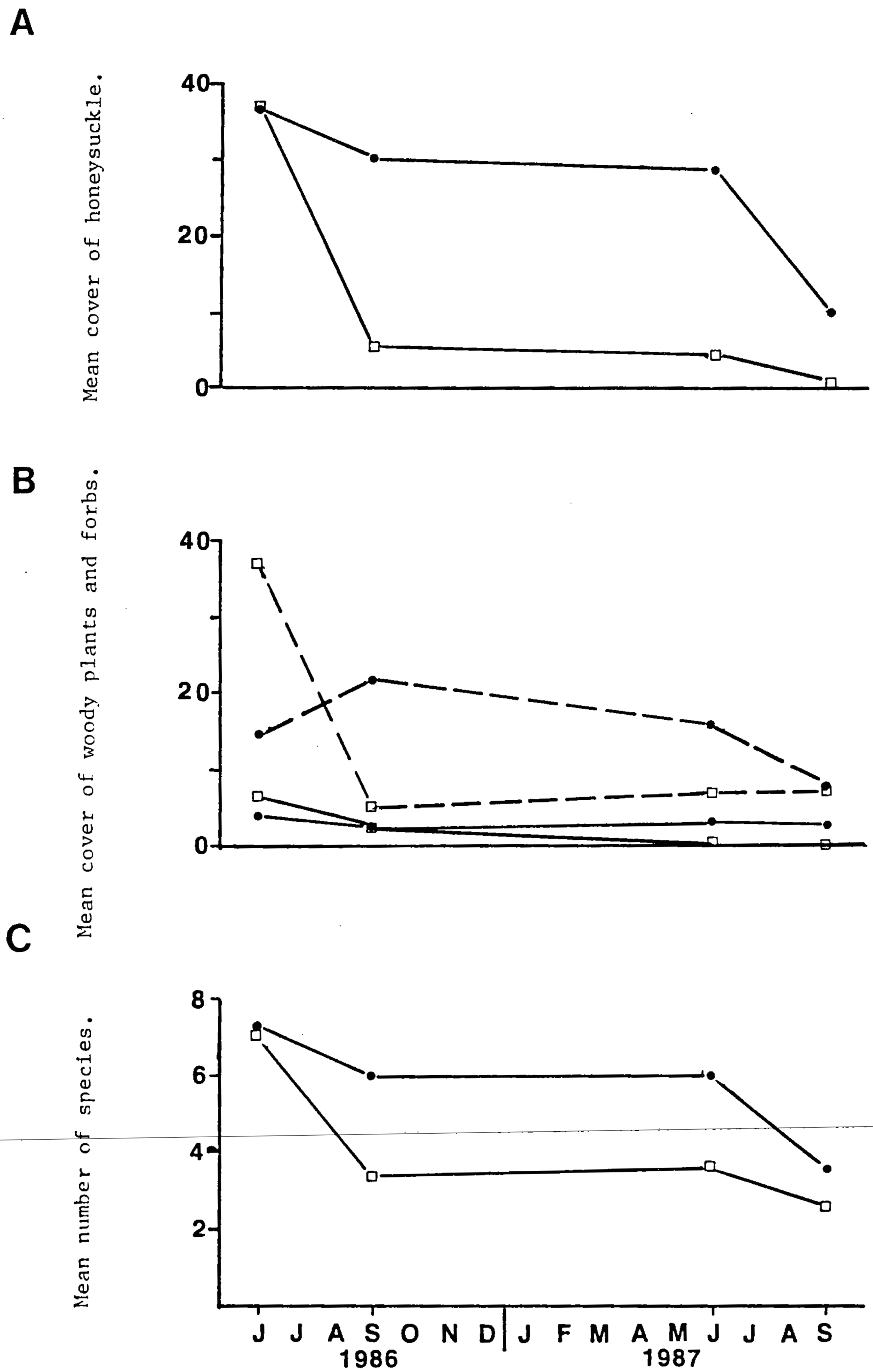

Figure 12. Trends in cover of Japanese honeysuckle (A) and woody plant (— —) and forbs (——) (B) and in species richness (C) during the course of the Harrison St. forest honeysuckle removal experiment. ● =control and □= herbicide application after first sampling.

Table 15. Results of Repeated Measures Analysis of Variance for the Harrison St. Japanese honeysuckle removal experiment. Values are F statistics.

Variable/effects	Constant	Polynomial Contrast Linear	Quadratic	Cubic
Japanese Honeysuckle				
time	111.83***A	33.94***	3.96	8.94*
treatments	15.67**	0.70	23.70**	0.28
Herbs				
time	30.32**	3.99	0.35	1.57
treatments	1.17	3.72	0.71	0.01
Woody plants				
time	96.01***	6.07*	5.75	7.27*
treatments	0.06	1.15	47.44***	10.84*
Species richness				
time	234.60***	22.49**	1.50	4.09
treatments	6.13*	0.13	7.59*	0.07

A *:P≤0.05, **:P≤0.01, ***:P≤0.0001

Table 16. Results of Repeated Measures Analysis of Variance for the Harrison St. Japanese honeysuckle removal experiment. Values are F statistics.

Variable/effects	Constant	Polynomial Contrast Linear	Quadratic	Cubic
Japanese Honeysuckle				
time	309.31***A	16.15**	16.04**	0.22
treatments	45.24***	5.02	16.90*	7.54
Herbs				
time	108.36***	0.05	0.13	0.01
treatments	0.11	4.39*	4.16	0.74
Grass				
time	22.57***	17.89**	2.92	1.07
treatments	5.85*	4.49*	1.14	0.85
Species richness				
time	556.97***	4.91	0.24	0.89
treatments	2.20	6.12*	0.11	1.11

A *:P≤0.05, **:P≤0.01, ***:P≤0.0001

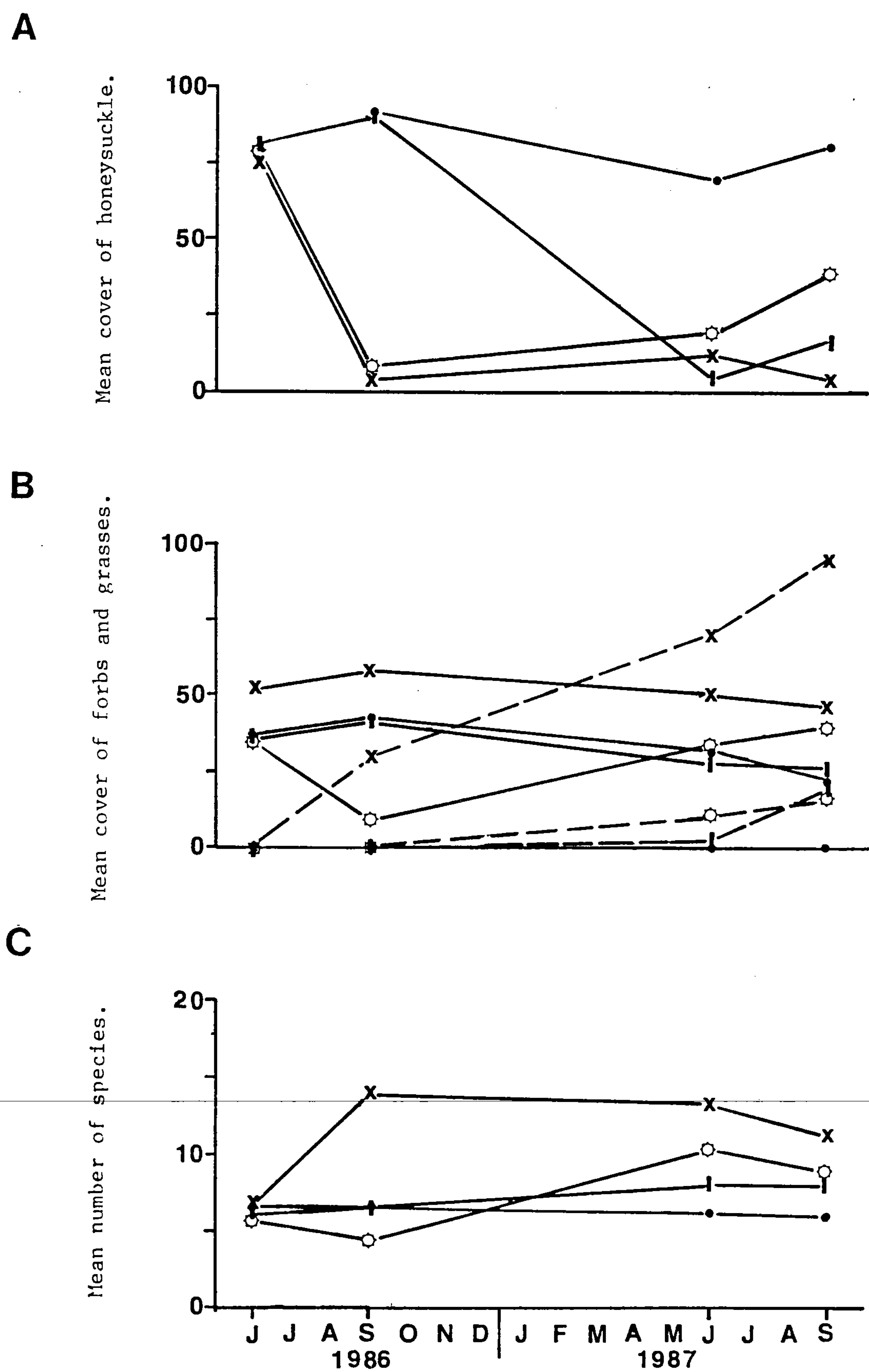

Figure 13. Trends in cover of Japanese honeysuckle (A) and forbs (——) and grasses (— —) (B) and in species richness (C) during the course of the old field honeysuckle removal experiment. ● = control, ✪ = vernal herbicide, ▮ = autumnal herbicide, and **X** = hand pulling.

increases in the grass cover and species richness relative to the other treatments. Since hand pulling occurred only 9 days prior to the herbicide treating, it is likely this differential effect represents seed bank release from soil disturbance, although time of seedling emergence relative to treatment application could also cause this difference.

For the three treatments analyzed statistically, forbs, grass and species richness showed marginally significantly different trends with time between treatments. These variables showed minor differences in trends with time compared to the hand-pulled plots. Only honeysuckle had significantly different trends (treatment-quadratic contrast) with time.

Species that increased in the treated plots included natives such as tickseed sunflower, buttonweed, panic grass, partridge pea, crossleaved milkwort, and purple foxglove. Weedy species that became common in the treatments were foxtail grass, sheep sorrel, plantain and crabgrass (especially in the hand removal plots).

Nonnative perennial grasses

The results from this experiment are (Table 17, Fig. 14, and Appendix D Fig. 3) unambiguous because of the homogeneous initial conditions across the treatments and the magnitude of the responses. The grasses were significantly reduced by the herbicide and herbicide+raking, but later increased with time to intermediate levels. The treatments differed significantly in their quadratic and cubic trends with time. The two treatments differed significantly from the controls in having a higher forb cover (constant contrast) and different trends with time (cubic contrast). Here we find a fourfold increase in forb cover in the treated plots relative to the controls. Species richness also showed significant increases in the treated plots relative to the controls. The treatments differed from the controls in the total species sampled (constant contrast) but also differed in their trends over time (linear contrast: increasing versus constant trends over time and cubic contrast: cubic versus horizontal trends over time). The two treatments show at least a threefold increase in species richness relative to the controls.

In spite of the lack of total elimination of Festuca and Bromus, there has been an increase in the cover of early successional forbs such as goldenrods. Species that invaded after the herbiciding included ragweed, tickseed sunflower, sheep sorrel, clovers, old field goldenrod, panic grass, plantains and crabgrass. If individuals had been counted this would represent a significant increase in density. Thus a nearly monospecific grass stand has been converted into a mosaic of early successional species and grass clumps which will go through natural succession at a higher rate than the control plots.

Table 17. Results of Repeated Measures Analysis of Variance for the homesite nonnative perennial grass removal experiment. Values are F statistics.

		Polynomial Contrast		
Variable/effects	Constant	Linear	Quadratic	Cubic
Nonnative perennial grass				
time	135.51***A	3.32	53.30***	37.74***
treatments	14.60**	2.25	12.98**	14.13**
Forbs				
time	48.27***	13.90	0.84	24.70**
treatments	5.93*	3.13	0.09	6.37*
Species richness	Constant	Linear	Quadratic	Cubic
time	180.28***	65.37***	1.81	66.37***
treatments	9.21*	21.36**	0.29	11.95**

[A] *:$P \leq 0.05$, **:$P \leq 0.01$, ***:$P \leq 0.0001$

Tree planting experiment

Tree survivorship is graphed in Figure 15. By September 1987, after a summer drought, 50% of the black oak, 43.9% of the white oak, and 21.7% of the pin oaks had survived. Black oaks appear tolerant of late summer drought that is common here. There is no consistent pattern relative to topographic position for the mortality. Counts of red maple stems indicated that this species had increased in density in the plots where it was pulled up! This is probably due to sprouting from root fragments that remained in the soil.

C2. Discussion

Removal of Japanese honeysuckle by hand pulling was most effective in increasing species richness and promoting growth of herbs. Impracticality of hand pulling, because of the difficulty and labor required, makes herbicide application most promising at forested sites. In the forested sites, honeysuckle regrowth is minimal. Unfortunately herbicide use in these conditions also eliminates herbs and tree seedlings; therefore, the planting of nursery stock herbs will be required to obtain a good ground cover. Application of glyphosate after the first hard freeze in the fall, may be more effective in eliminating honeysuckle only, but this strategy was not tested. Elimination of Japanese honeysuckle will nevertheless require a long term intensive effort.

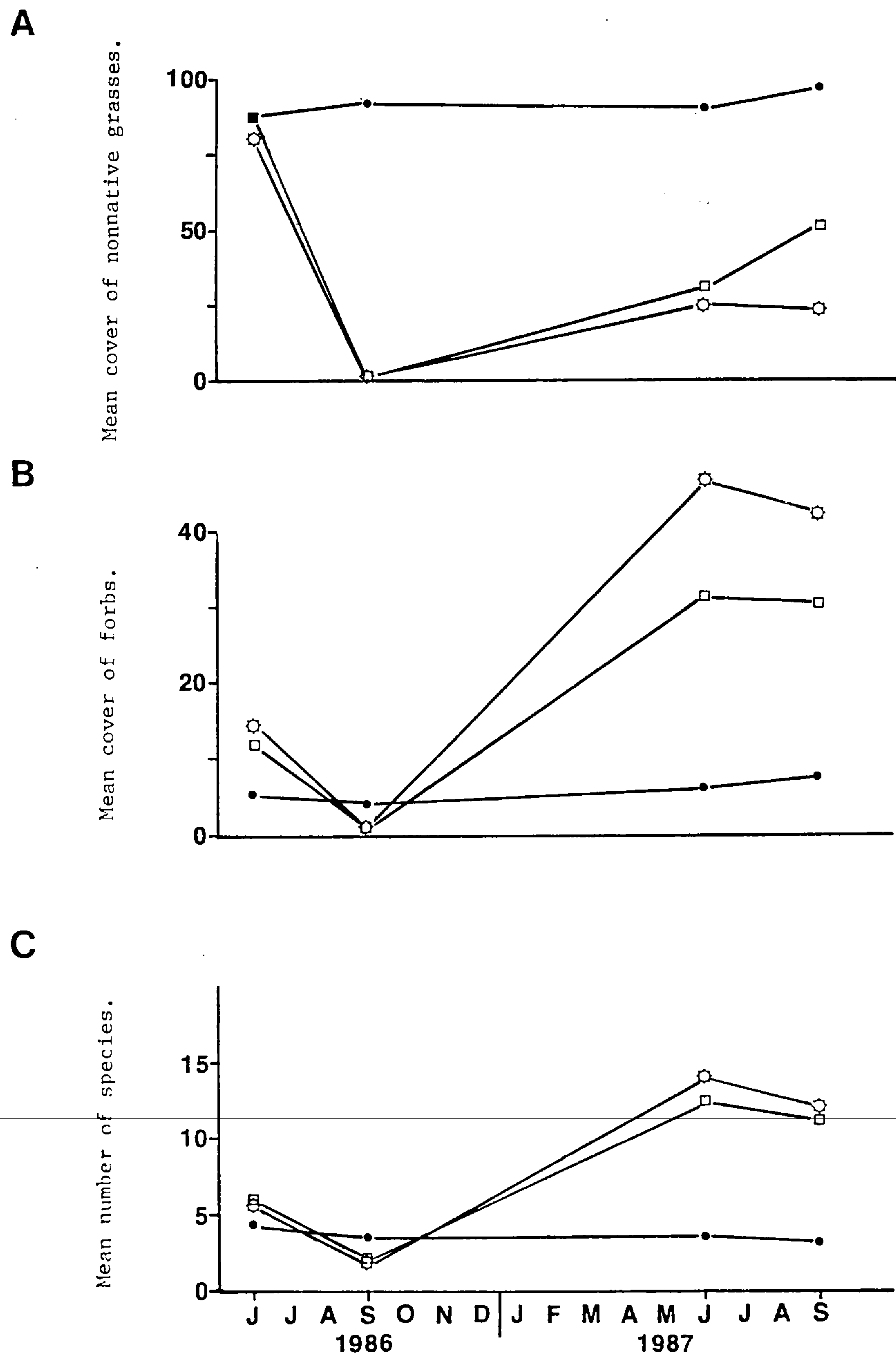

Figure 14. Trends in cover of nonnative grasses (A) and forbs (B) and in species richness (C) in the exotic grass removal experiment. ● = control, □= vernal herbicide after first sampling, and ☼= vernal herbicide + removal of dead biomass.

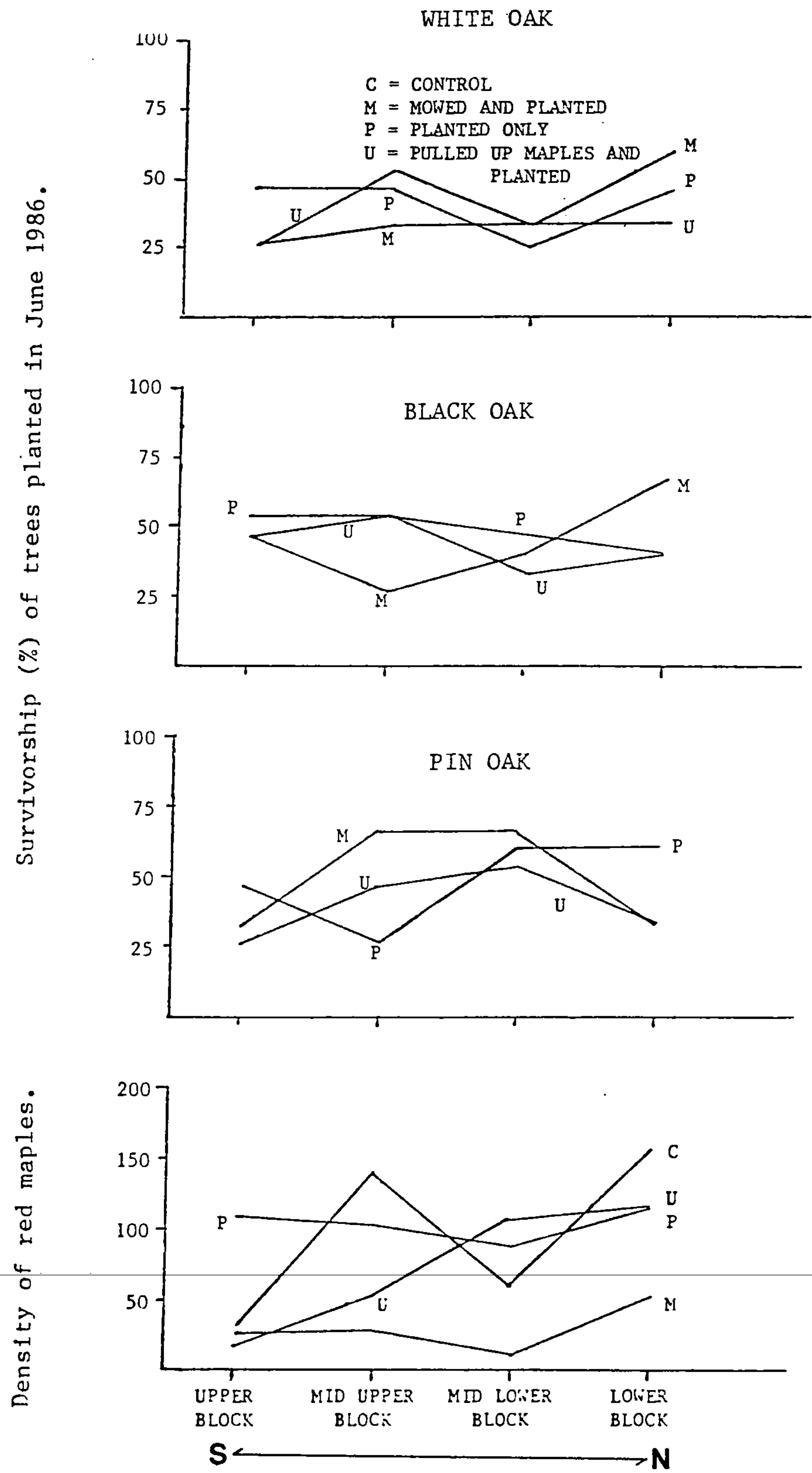

Figure 15. Tree survivorship and red maple density in the tree planting experiment.

The cover of exotic lawn grasses is effectively reduced (not eliminated) by the application of glyphosate. This is a quick method of facilitating the germination and establishment of old field herbs that will accelerate natural succession.

Desirable tree species planting alone may be ineffective in low mesic sites to achieve the desired tree cover because of red maple competition. In the old fields, planting may be the only means of establishing some species, but it should be recognized that sapling survivorship may be low in some years. Herbivore grazing may reduce survivorship and reduce height growth (some grazed seedlings were observed in 1987). Natural seedlings of shingle oak were first observed in the old fields in the fall of 1987.

MANAGEMENT RECOMMENDATIONS

At the outset it must be realized that not all natural disturbance processes can be restored to a 200-acre area that is dissected by roads. It is possible to approximate them with management. Some factors may occur more frequently due to fragmentation, such as wind throw at the boundary between farm land and an old growth forest and perhaps grazing pressure from deer (Schonewald-Cox and Bayless, 1986). Exotic invasion will be increased due to the large boundary to area ratio. Other factors such as fire will be reduced due to suppression. Restoration and maintenance of presettlement vegetation at LBNM will require active long-term management. The authors believe that this can be done; however, 200 acres may not be large enough to provide sufficient disturbance patch frequencies, patterns and scales to ensure the persistence of all species currently present.

To facilitate the easy perusal of the results, this section is separated into two sections: 1). concerning each vegetation type in the park and 2). management recommendations for each of the park units. Methods for restoration will be given hierarchically, ranging from the no action option to techniques to recreate the presettlement vegetation.

A. RECOMMENDATIONS BY VEGETATION TYPES.

1. The Old Fields

These disturbed areas contain a mixture of exotic weeds and native herbs. Many of the native herbs appear to grow in native savanna-like communities. It is unclear in what type of presettlement community these species were found (personal observation and Homoya, pers. comm.), but they could have persisted in forest openings. Since these fields were abandoned in 1973, they have developed rather rapidly. Harrison and Werner (1984) found that tree invasion occurred 15 years after abandonment in a south Michigan old field. Red maple appears to be invading on the lowest and intermediate topographic positions, but other species such as sycamore, black cherry, persimmon, white ash and a few oaks have been observed with red maple on higher topographic positions. Only in 1987 have shingle oak seedlings first appeared in these old fields. Nevertheless the presence of senescent black and white oaks along the north fence row, suggest that oaks were predominant in the upper old fields area in the past.

The following management alternatives exist for these old fields:

1). Leave them to change naturally.
2). Accelerate succession by tree planting.
3). Select for less mesic species by performing controlled burning.

Under alternative 1, these fields would develop into mesophytic bottomland forest dominated by red maple and sycamore. Such a low diversity mesophytic forest would be as aesthetically pleasing as any, but would fail to represent a presettlement community. Little oak (except shingle oak perhaps) or hickory would ever become established under such conditions. The failure of oak reproduction is probably the result of a lack of local sources of acorns and nuts for dispersal by birds and mammals. It is possible that insufficient time has elapsed to allow oak invasion into the old fields.

Tree planting and/or controlled burning would facilitate the development of a diverse forest community, by respectively introducing biotic dispersed tree species and by eliminating the fire intolerant mesic species. Under the current fire management plan the latter is unfeasible. Planting of trees would introduce structural heterogeneity that would enhance the immigration of seed dispersing animals. Options 2 and 3 would likely produce a community composition closer to that of presettlement vegetation.

The north portion of LBNM is surrounded on three sides by roads or railroad tracks which would provide sufficient fire breaks once a fire management plan was approved. This area would be the best to try prescribed fire management on a frequency of 20 to 40 years perhaps to encourage oak and hickory reproduction. A control area could be set aside to validate the effects of fire on forest composition. A third of the "North Forty" could be a control and another third could be burned (Figure 16).

2. Lawns and Pastures

Numerous old lawns on the "North Forty" and pastures west of CR A will need to be restored to native vegetation in the future. Studies at Indiana Dunes by Ronald Hiebert (1986) have demonstrated that these introduced grasses preempt a site for at least 15 years and arrest succession. No action, therefore, would result in retarded community change.

The lawn management experiment discussed previously provides guidelines as to how to eliminate nonnative grasses. Application of glyphosate in the spring when the grasses are rapidly growing should kill most of the grasses. A post treatment raking to eliminate the dead grass biomass would also release the seed bank by providing more light at the soil surface and stir the soil to expose seeds. This should facilitate natural succession of the site.

3. Drives and Old Roads

All drives and roads in the "North Forty" often were covered in limestone, a rock which raises the soil pH (Table 4) and modifies the soil drainage by increasing soil compaction. This substrate modification allows nonnative herbs such as white sweet clover to invade and persist. Since most of the natural

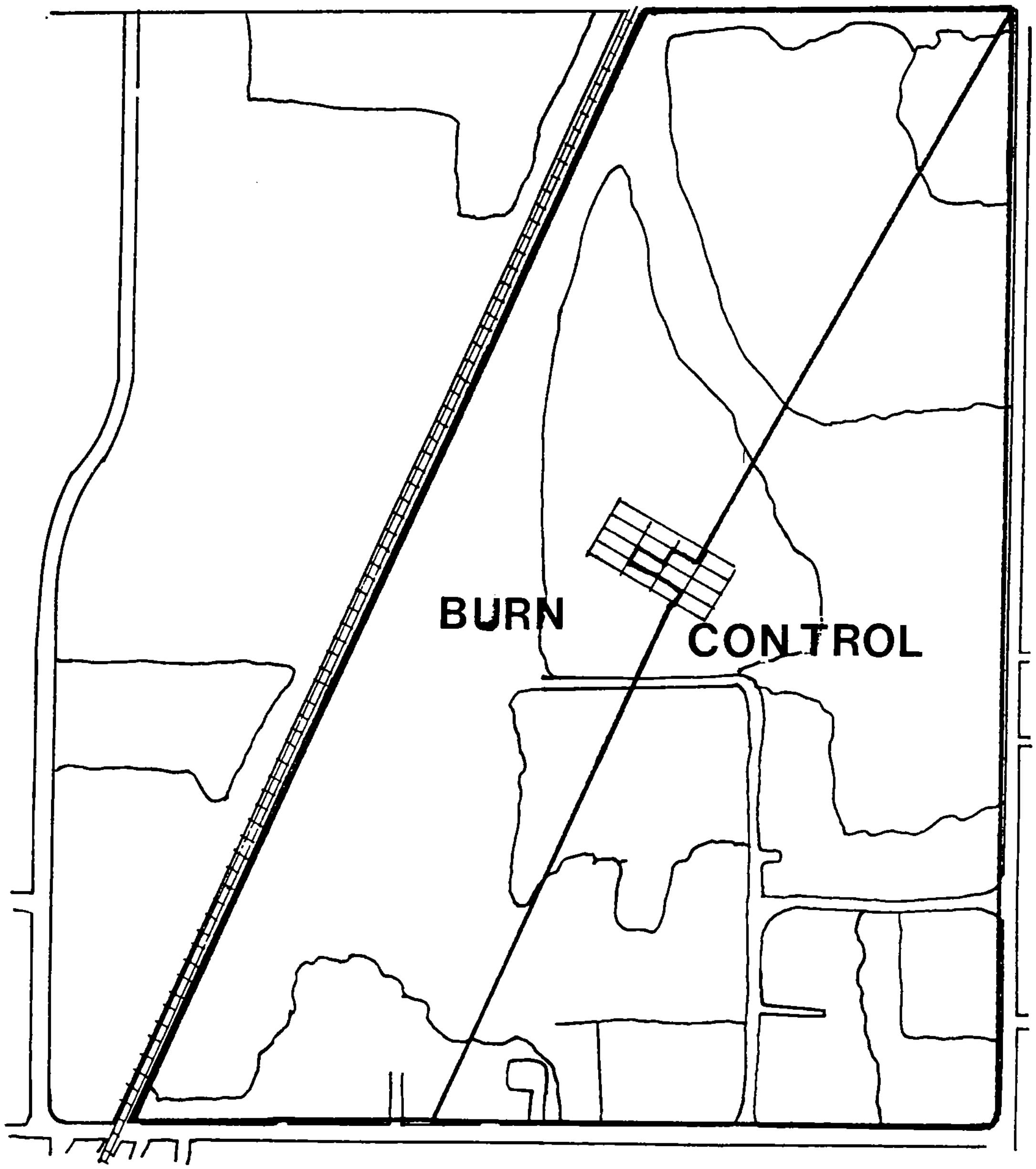

Figure 16. Proposed prescribed burn area for the North 40. The purpose of the fire is to examine the affects of infrequent fire on the composition and structure of the bottomland forest.

soils here tend towards acidity, unusual vegetation develops on these sites. Therefore, removal of limestone gravel is recommended followed by addition of local soil to facilitate natural succession.

4. **The Mixed Maple/Tulip-tree Plantation.**

Very little information is available on the reforestation work done in the early 1930's. An effort was made to plant local stock but a species planting plan suggests species unknown from this part of Indiana may have been planted (Wilson, 1929); however, no evidence of unusual species planting was found. The forest composition suggests planted species were mostly red maple, sugar maple, and tulip-tree. If oaks and hickories were planted, no evidence of such was found. The forest composition at present fails to reflect any natural presettlement forest. Sugar maple was probably never this abundant in the immediate area. In a survey of the Lincoln State Park, which has been less disturbed, Mike Homoya and John Bacone saw only a few sugar maples. Much of the east end of the forest (LBNM) lacks a shrub understory which is probably a result of the shrub removal done in 1963-64 as initial cleanup (Adams, 1986a & c). Apparently the superintendent at that time wanted to turn the site into a groomed park (Adams, 1986b).

These forests contain late successional/shade-tolerant tree species. Tulip-tree would most likely be eliminated in the future since it is intermediate in shade tolerance and since it is incapable of reproducing under a maple canopy.

The management alternatives for these planted stands include:

1. Leave the forest and let nature take its course.
2. Remove most of the trees and replant with species more characteristic of the presettlement vegetation.
3. Create canopy gaps by removing some trees and plant within them species characteristic of presettlement vegetation.

Alternative 1 would cost nothing but result in a late successional forest of maples. Alternative 2 would be the most costly and damaging to the area. Visitors would object to a clearcut in the park. But this could be the most likely option to succeed in producing a presettlement type of vegetation, especially if fire were used after several years to eliminate mesic invader species. Option 3 would be less costly, less damaging, and more compatible with the use of the park. This long-term option has no guarantee that it would be successful because the desired hardwoods may not grow fast enough to outgrow maple and tulip-tree reproduction unless these were specifically suppressed. If option 3 were implemented, then removal of all Japanese honeysuckle within and adjacent to the proposed gap would be required. Otherwise gap creation would provide a suitable habitat for rank honeysuckle growth. Gaps could be created by cutting trees out of a 1/4 to an acre area. Stumps of undesirable species might need to be contact herbicided or burned to ensure they failed to resprout. Planting might be done to mimic natural succession with red cedars and persimmon being planted first with oaks and hickory being planted beneath them.

5. **The old growth forest.**

Increment tree coring demonstrated a minimum age for the stand of 147 years. This result, in conjunction with early visits to the Nancy Hanks gravesite circa 1865 (Santosuosso, 1970), indicates the forest was perhaps never cut over since it was 'densely wooded' at that date. Nevertheless the forest was probably disturbed in the understory soon after 1816, perhaps by hogs, particularly since hogs eat and destroy spring ephemerals. This conjecture is further substantiated by the remnant jack-in-the-pulpits and poison ivy as dominant understory species. Bierzychudek (1982) notes the former species contains crystals of calcium oxalate which deters predation. Interviews with personnel working in the park soon after it was turned over to the National Park Service indicate the understory was cleared out as recently as 1963. At that time it was thought the park would be managed as a groomed park with perhaps lawns beneath.

This study has identified several problems needing to be addressed in the old growth forest: 1) The absence of oak and hickory reproduction in the understory and the invasion of sugar maple upslope in the north facing ravines; 2) The presence of subcanopy sugar maples in the west facing slope without seedling reproduction.

Failure of oak and hickory reproduction and the invasion by maple.

The absence of oak and hickory reproduction is the most intractable problem in the old growth forest. Whether this represents the normal condition for such forests or is a result of past management is unclear. Numerous studies from similar forests in the Midwest indicate this process is pervasive (Barton and Schmelz (1987), Parker et al 1975, Schmelz et al 1975 and Hagan and Runkle 1987); however the lack of reproduction and the profusion of maple reproduction may be a successional process which was initiated in post settlement times by fire suppression, land use practices or climatic changes. Many of the studies cited above demonstrate an increase in the importance of maples and beeches and a concomitant loss in the importance of oaks and hickories. Sork (1983) found that pignut hickory was able to germinate when buried in both fields and forests, but the seedlings grew better in transition and edge zones and that predation by mammals eliminated most nuts in the forest. Thus pignut hickory replacement only occurred in transitional and edge habitats. This suggests a minimal gap size sufficient to provide safe sites for seedling establishment. Perhaps with fire suppression, open intercrown areas where oak and hickory would have regenerated, have been invaded by shrubs and saplings. Competition by the dense vernal understory of maple seedlings has perhaps discouraged oak and hickory reproduction.

Paul Johnson (pers. comm.) believes the oak-hickory forests of the Midwest resulted from irreproducable historical events in time and space which involved disturbance and fire history. He contrasts mesic with xeric forest stands in how oak reproduction occurs. Xeric forests are reproduction accumulators because of the species that grow there and because of the xeric conditions. Such species (black and white oak) produce seedlings, sprouts, and grubs which are able to reach the canopy in large gaps due to the mature age roots which can grow at a fast rate. Without the production of large roots, these species are unable to grow fast enough to reach the canopy. Repeated disturbance such as fire can produce an accumulation of oak reproduction.

In mesic forests rapidly-growing, shade-tolerant species replace the dominant oaks. Species such as red oak are capable of rapid growth to reach the canopy without prior massive root growth. Here, large canopy gaps are required for oak regeneration. The burning prescription required for this mesic regeneration is unknown according to Paul Johnson.

As previously mentioned, sugar maple was probably rare here in presettlement times and beech was probably absent. Consequently, the current maple invasion problem is a result of the introduction of sugar maple by settlers and their encouragement by fire suppression and release when understory disturbance ceased. Judging from the age of the maples (of the trees cored: 55.7 years in the old growth and 57.5 years in the reforested communities) and from knowledge that the land surrounding the old growth forest was pasture until the 1920's (see Appendix A in York (1984) and unpublished 1934 topographic map of Central Portion of Lincoln Memorial State Park by E. C. W. Camp), it is reasonable to believe the maples were only able to invade when pasture abandonment occurred. Inferring future replacement by maple from dense seedlings is untenable because sugar maple seedlings are subject to high mortality (Hett 1971). But the above mentioned references demonstrate this phenomena is occurring throughout the Midwest. Active management will be necessary to suppress the invasion of mesic species and to encourage the reproduction of the oaks and hickories. Below is a listing of the possible management tools to address this problem.

1. No management.
2. No manipulation with option to later start management.
3. Use controlled burning to suppress the mesophytic invaders and to encourage oak and hickory reproduction.
4. Plant oak and hickory seedlings in canopy gaps to facilitate their reproduction.
5. Remove maple saplings by hand.

Alternative 1 would allow the forest to undergo succession given current conditions. This would lead to a more mesophytic forest dominated by maple, walnut, white oak, red elm, and other species on the northerly facing slopes. More xeric slopes would be resistant to mesic species invasion. This option would probably mean the loss of characteristic oak-hickory dominants in the next 50 years or so, since many of the black oaks are quite old. This would result in the elimination of a forest type characteristic for the region at the time of the Lincoln settlement.

Alternative 2 would permit tracking the successional trends of the forest through 10 to 20-year sampling intervals from the permanent plots with the later option to manipulate the site. This conservative option would lessen the chances of making an incorrect successional interpretation based solely on the present information (which represents a small fraction of the lifespan of the trees being studied). Later management decisions would perhaps be better since they would be based on more information. A recent article (McCune & Cottam, 1985) highlights ecologists' reservations in predicting successional trends in forests beyond the lifespans of the existing trees because of random unpredictable events which greatly affect their future composition.

Alternative 3 is untenable since the area surrounds the historic graveyard and the superintendent (pers. comm.), disfavors the use of this management tool in this part of the park. Too frequent fire might suppress hickory reproduction (Fowells, 1965 and Fralish, pers. comm.) and have an undesired effect on a senescent old growth forest such as this. Option 3 might also require plantings as in Option 4, since seed reproductive failure appears to be the norm for the senescent black oaks.

A combination of options 4 and 5 would seem to be reasonable approaches to these problems. No other research studies shed light on the proper management tools to maintain such forests. The invasion of maple is most pronounced on the north and northeast facing coves of the forest. The data collected in this study is insufficient to determine whether maple is actually invading or whether there is only a stable static ecotone. Also tulip-trees which were uncommon in presettlement times may in the future invade the hardwood forest. Upland successional forests south of this stand contain this species, which has presumably invaded from the adjacent Allee planting between the Memorial Building and the flagpole south of the graveyard.

The presence of sugar maples on the west slopes.

The several large maples on the west facing slope were found to range in age from 56 to 72 years. Reproduction was noticeably absent underneath and in nearby canopy gaps. We contend that this slope is too dry for natural maple invasion and that these trees were planted around the outhouses and trails leading up to the cemetery around 1914 and 1929. This conjecture is likely since three of the four trees cored were about 56 years old. These trees can probably be cut down manually with chain saws to reduce the impact on the surrounding forest. Also attempts should be made to remove the exotic shrubs that were planted along the trail near the former bone yard. These actions would require little time and money to perform and would provide additional habitat for oak and hickory reproduction.

Spring ephemeral herbs: Their absence

Absence of showy spring wildflowers had been noted by LBNM personnel; consequently, attention was made to sample these species. Appendix C (spring ephemeral section) summarizes the mean frequency of the herbs for each community. Many of the species are found in the mixed hardwoods, old growth hardwood forest of LBNM and LSP and in the bottomland hardwood forest. High frequencies of spring beauty (Claytonia virginica), jack-in-the-pulpit (Arisaema atrorubens), cut-leaf toothwort (Dentaria laciniata), and trout lily (Erythronium americanum) occurred in the LSP hardwood forest relative to the LBNM upland hardwood forest which suggests the latter was disturbed. Nevertheless some species were found only in the LBNM hardwood forest, but were very rare: white trout lily (Erythronium albidum), rue anemone (Anemonella thalictroides), wood sorrel (Oxalis violacea), Solomon's seal (Polygonatum biflorum), and smooth yellow violet (Viola pennsylvanica). Other notable herbs found in the LBNM hardwood forest include Virginia bluebells (Mertensia virginica, probably planted) and goldenseal (Hydrastis canadensis).

The LSP woods has a rich spring flora of spring beauty, prairie trillium (Trillium recurvatum), mayapple (Podophyllum peltatum), bloodroot (Sanguinaria canadensis), and trout lily to name a few species. The best vernal display at LBNM occurs in the mesic hardwood forest. Other communities have vernal geophytes; however, they are very infrequent. In spite of using the bottomland forest area as a dump in the past, it has a rich carpet of bedstraw (Galium aparine), phacelia, common blue violet (Viola papilionacea) and sweet white violet (Viola striata).

We recommend the initiation of a spring herb planting plan with plants propagated in a nursery from locally collected seeds. Shirley Gates initiated a spring ephemeral planting experiment in the spring of 1987 (Appendix G). The results from this effort are encouraging in that some plants germinated and survived the preceeding dry years. Planting in combination with some hand pulling of Japanese honeysuckle in small areas could result in the expansion of forest herbs in the long run. This should be first done in the upland hardwood forest where honeysuckle is infrequent and in herbaceously denuded portions of the planted forests. Ant species introduction might also be beneficial since these Hymenoptera disperse spring herb seeds (Culver and Beattie 1978, Beattie et al. 1979, and Pudlo et al. 1980).

B. RECOMMENDATIONS BY PARK UNIT.

Restoration and creation of presettlement type vegetation will require intensive management and as such should be justified in the park's Resource Management Plan. Many of the recommendations below should be written as action statements in the resource management plan if they are adopted. Student interns, etc. trained in biology can be invaluable in conducting this management. Although we have provided guidance as to how to restore the vegetation, the day-to-day work will require an open-minded, experimental approach, since many techniques may be unsuccessful.

1. The "North Forty"

Since this unit has been the most anthropogenically disturbed, it will require the most work to restore. On the other hand, since it is largely in an early successional stage it can be worked more easily to start anew. Here we recommend the following steps to restore this area.

1. Revise the Resource Management Plan and the Wildland Fire Management Plan to permit prescribed burning to investigate the role of fire in initiating oak-hickory communities rather than mesophytic tree dominated communities. Fire season was probably in the late summer and autumn since the ground is water-saturated at other times of the year.
2. Use glyphosate to reduce the successional inertia caused by nonnative perennial grasses at old home sites.
3. Eliminate Japanese honeysuckle in forested stands using glyphosate and reintroduce native vernal herbs once honeysuckle has been reduced. Soil disturbance may assist in releasing the native seed bank if it still exists.
4. If weedy old roadbeds remain a problem, then remove gravel and replace it with local soil. Roadbeds of gravel represent an alkaline (basic) soil condition which is uncommon in this area.

2. The Lincoln Living Historical Farm Unit.

All of the forests of this unit appear to have been planted and fail to represent a natural community type. If recreation of oak-hickory forest is the desired goal, than the following steps will be required, excluding the farm area.

1. Elimination of Japanese honeysuckle (or remove after the desired overstory has been successfully introduced).
2. Planting of native herbs to replace the honeysuckle.
3. Creation of canopy gaps where oak-hickory forest species will be planted. Tulip-trees and sugar maples will need to be removed if the oak-hickory species are to regenerate.

3. **The Cemetery Hill Unit.**

Here, the goal should be to maintain the upland hardwood forest since it is the type present at settlement. Also the surrounding planted and successional forests will need to be monitored for invasion of sugar maples and tulip-trees which can alter the forest composition. The following management goals will be necessary.

1. Remove sugar maples from the old growth upland hardwood forest and ensure they fail to invade by periodic removal.
2. Propagate and plant native vernal herbs to restore the herbaceous vegetation.
3. Monitor tulip-tree invasion into the old growth forest, because they could be the first stage of mesic succession.
4. Alter the planted forests as suggested above.

4. **The West Unit.**

This is a very diverse unit with pastures, an upland old field and successional mesic and upland hardwood forests. The preparation of the pastures after abandonment will require management like that for the lawns. The forests have a mixed hardwood composition which resembles presettlement vegetation. Longterm monitoring is all that will be required for these stands to assess the potential of shade-tolerant, mesic species invasion. The upland old field represents a distinctive floristic community for this region, but may not represent a presettlement community. Given the small size of the park, it is unlikely that maintaining this community by a spatial disturbance mosaic in time will be possible.

RESTORATION PRIORITIES

Restoration priorities are quantified by classifying vegetation units on the following criteria: ecological significance, historical significance, relative restoration cost, and urgency and practicality of restoring the site (Table 18). Priorities are based on the premise of site restoration to the vegetation type existing circa 1816. Below is a discussion of how the rankings in Table 19 were arrived at. These may be changed upon further consultation.

RANKINGS OF THE FOREST UNITS IN THE REFORESTATION MATRIX

Ecological significance

Both the bottomland and oak hickory, are given ecological ranking of 1 because they represent relatively undisturbed natural communities, have a variety of native plant species and have few exotic species. Successional forest in the west unit is given a value of 2 rather than 3 as elsewhere, because this stand has a rich, abundant spring ephemeral flora that is nowhere equaled at Lincoln Boyhood.

Reforested areas and successional forest (Cemetery Hill) are ranked as 3 since they fail to represent a natural presettlement community, they are rich in exotic species and they have a depauperate native herb layer. But they are forests so they are ranked lower than some of the following communities.

The old fields are given a ranking of 3. They are an anthropogenic community, which is dominated by native herbs and forbs, but if disturbed exotic annuals become temporarily dominant. A ranking of 4 would be inappropriate since exotics are of little importance. Both the old homesites and roadbeds are dominated by exotic graminoids and forbs resulting from anthropogenic disturbance. They are given a ranking of 5.

Historical Significance

Historical significance is based on whether the natural feature was present from 1805 to 1830 and how much it played a role in the life of the Lincolns. On this basis it is logical to assign remnant oak-hickory forest a value of 1 since it was present and it is where Nancy Hanks Lincoln is buried. The bottomland forest was present in 1816 and was perhaps minimally used by the Lincolns. It is assigned a rank of 2.

Reforested communities are given a ranking of 3 because they are historically significant as attempts to recreate the presettlement forest but have no significance in terms of the Lincoln years. Successional forests, upland and lowland old fields, homesites and roadbeds are only historically important in terms of recent human activity and have no other historical significance. Thus these are assigned values relative to their age of abandonment.

Table 18. Criteria for ranking the vegetation units.

ECOLOGICAL SIGNIFICANCE:

low values - natural plant communities
presence of unusual native species
few exotic weedy species

high values - anthropogenic plant communities
presence of exotic weeds
native species of low importance

HISTORICAL SIGNIFICANCE:

low values - vegetation present in 1816

high values - post 1830 anthropogenic vegetation

RELATIVE RESTORATION COST: see subsequent information

low cost - little expenditure in restoration materials and employee time
short duration of management

high cost - considerable expenditure for restoration materials such as trees and plants
long duration of management

URGENCY FOR RESTORATION:

low values - urgent since a delay would result in degradation through successional processes
delay would result in increased costs for restoration
delay would result in an increase in management effort
high park priority

high values - delay would not result in loss of resource
costs would remain constant or decrease with time
management effort would remain constant or decrease if action was delayed
low park priority

PRACTICALITY: Values are based on community mean action practicality scores.

low values - little effort required in restoring

high values - considerable and concerted long term effort will required to restore

Table 19. Lincoln Boyhood National Memorial restoration priority matrix.

AREA	ECOLOGICAL SIGNIFICANCE	HISTORICAL SIGNIFICANCE	RELATIVE COST	URGENCY	PRACTICALITY	PRIORITY TOTAL
North 40:						
Old fields	4	5	6	1	4.5	20.5
Homesites	5	5	2.2	3	1.5	16.5
Roadbeds	5	5	3.3	3	2.7	19.0
Farm:						
Reforested areas	3	3	5.3	3	5.3	19.3
Bottomland	1	2	2	4	3.5	12.5
Pasture (to remain)	-	-	-	-	-	-
Cemetery Hill:						
Oak-hickory	1	1	3.4	1	4.1	10.2
Reforested areas	3	3	5.6	3	5.6	20.2
Successional forest	3	4	2	4	2.3	15.3
West Unit:						
Upland old field	4	5	3.7	2	3.3	18.0
Pasture (to remain)	-	-	-	-	-	-
Successional forest	2	3	3	4	4.5	16.5

Relative Restoration Cost

Relative restoration cost is based on the time, effort and materials needed to restore the community (Table 20). To determine the relative cost it is important to have an idea of what activities will be involved (Table 21). Estimates of restoration costs are based on this information and are qualitatively estimated in Table 22.

The qualitative cost scores are then summed for each community, divided by the number of actions to yield the average cost score which is multiplied by an area coefficient (proportional to the area of land to be restored) to give the final restoration cost scores (Table 22). It is these restoration scores which are entered in Table 19.

Urgency of Restoration

Restoration in the old fields is very urgent if an oak dominated community is desired, because red maple invasion will make it increasingly difficult to obtain such a community. The oak-hickory forest will degrade without the removal of sugar maple and Japanese honeysuckle.

Homesites, roadbeds and reforested areas are less urgent. The first two are fairly stable, but eventually some woody species will invade and make it more difficult to remove the

Table 20. Estimates of restoration and management costs by activity.

Activity	Manpower	Materials	Cost
Sugar maple removal	1 (4 days)	girdle trees	1
Tulip-tree removal	1 (6 days)	girdle trees	2
Red maple removal (prescribed burn)	1 (20 days)	write burn plan approval	5
	10 (5 days)	fire fighting equipment	
Trash removal	Volunteers	Plastic bags	1
Shrub removal (cutting)	1 (3 days)	Chain saw	1
Shrub removal (prescribed burn)	1 (20 days)	write burn plan approval	5
	10 (5 days)	fire fighting equipment	
Grass removal (glyphosate)	1 (2 days)	applicator glyphosate	1
Honeysuckle removal (hand)	2 (3 days)	Gloves	3
Tree planting	5 (2 days)	seedlings	3
Roadbed gravel removal	2 (3 days)	bulldozer	3
Replacing soil	3 (4 days)	obtain soil	3
Honeysuckle removal (glyphosate)	1 (5 days)	applicator glyphosate	2
Herb nursery and planting	2 (20 days)	collect seed and plants	4
Canopy gap formation	3 (10 days)	chainsaw	4

exotic grasses. Japanese honeysuckle should decline in abundance as the reforested communities mature, which will make honeysuckle easier to eliminate. The bottomland forest is fairly intact although abundant trash and some Japanese honeysuckle are present.

Practicality of Restoration

Practicality is best based on each restoration action needed in each community rather than ignoring that some restoration actions may be easy and others more difficult in the same community. The rankings are therefore based on the average restoration action practicality scores for a particular community. Restoration rankings are given in Table 23.

Homesites are easy to restore solely by glyphosate application. Restoration of the oak hickory forest will only require some herb planting, sugar maple removal, and hand removal of Japanese honeysuckle. Shrub removal (later try burning?) in the cedar glade is quite easy. Trash and honeysuckle removal in the bottomland will require little effort. Honeysuckle removal in reforested and successional areas by glyphosate application should be easy but lengthy in terms of the area to cover.

Table 21. Types of activities to rectify the management problems by park unit and vegetation type.

PARK UNIT	VEGETATION	PROBLEM	ACTIONS
North 40	Old fields	red maple invasion	prescribed burn
		paucity of oaks	tree planting
	Homesites	exotic grasses	herbicide application
	Roadbeds	exotic soil & plants	gravel removal
			apply local soil
			revegetate sites
Farm	Reforested	remove honeysuckle	apply herbicide
		introduce native herbs	nursery and planting
		restore canopy	remove maples & tulip-trees
			plant oaks & hickories
	Bottomland	trash dump	remove
		Japanese honeysuckle	hand remove?
	Pasture	to remain	no action
Cemetery Hill			
	Oak-hickory	sugar maple invasion	cut down or girdle
		Japanese honeysuckle	hand remove?
		sparse spring herbs	propagation and planting
	Reforested	remove honeysuckle	apply herbicide
		introduce native herbs	nursery and planting
		restore canopy	remove maples & tulip-trees
			plant oak & hickories
	Successional forests		
		remove honeysuckle	hand remove?
		introduce native herbs	nursery and planting
		restore canopy	remove maples & tulip-trees
			plant oaks & hickories
West Unit	Successional forests		
		remove honeysuckle	fall herbicide
	Upland old field	red maple invasion	cutting or prescribed burn
		paucity of oaks	tree planting

Restoration of the herb, shrub and tree layers will require more long term effort. Old field restoration is less practical because a prescribed burning plan must be developed, approved andimplemented. Tree planting will be easy, but Japanese honeysuckle invasion from forested edges will be a major problem.

Discussion

Most urgent is the restoration of the upland oak-hickory and the bottomland forests to prevent further deterioration. For the former this will involve sugar maple and Japanese honeysuckle removal and herb planting and for the latter, trash and Japanese honeysuckle removal. Further research may be required to develop

Table 22. Restoration cost scores. Low values refer to inexpensive actions.

ACTION	SCORE	NORTH 40			FARM		CEMETERY HILL			WEST UNIT	
		OF	HS	RB	RF	BL	OH	RF	SF	OF	SF
Sugar maple removal	1						X	X	X		
Tulip-tree removal	2								X		
Red maple removal (prescribed burn)	5	X								X	
Trash removal	1					X					
Shrub removal (cutting)	1						X				
Grass removal (glyphosate)	1		X								
Honeysuckle removal (glyphosate)	2				X			X			X
Honeysuckle removal (hand)	3					X	X		X		
Tree planting	3	X	X		X			X		X	
Herb nursery and planting	4			X	X		X	X			
Roadbed bulldozing	3			X							
Replacing soil	3			X							
Canopy gap formation	4				X			X			
Score sum		8	4	10	13	4	9	14	6	8	2
Total management actions		2	2	3	4	2	4	5	3	2	1
Mean score		4.0	2.0	3.3	3.3	2.0	2.3	2.8	2.0	4.0	2.0
Estimated area (hectares)		4.4	1.7	0.4	5.9	1.7	5.7	16.5	1.9	1.1	6.6
Area coefficient		1.5	1	1	1.5	1	1.5	2	1	1	1.5
Cost score		6.0	2.0	3.3	5.3	2.0	3.4	5.6	2.0	4.0	3.0

Table 23. Restoration action practicality scores. Low values refer to practical actions.

ACTION	SCORE	NORTH 40			FARM		CEMETERY HILL			WEST UNIT	
		OF	HS	RB	RF	BL	OH	RF	SF	OF	SF
Sugar maple removal	1						X	X	X		
Tulip-tree removal	1								X		
Red maple removal (prescribed burn)	4	X								X	
Trash removal	1					X					
Shrub removal (cutting)	2						X				
grass removal (glyphosate)	1		X								
Honeysuckle removal (glyphosate)	3				X			X			X
Honeysuckle removal (hand)	5					X	X		X		
~~Tree planting~~	~~2~~	~~X~~	~~X~~		~~X~~			~~X~~		~~X~~	
Herb nursery and planting	3			X	X		X	X			
Roadbed bulldozing	2			X							
Replacing soil	3			X							
Canopy gap formation	5				X			X			
Score sum		6	3	8	14	7	11	14	7	6	3
Total management actions		2	2	3	4	2	4	5	3	2	1
Mean score		3.0	1.5	2.7	3.5	3.5	2.7	2.8	2.3	3.0	3.0
Estimated area (hectares)		4.4	1.7	0.4	5.9	1.7	5.7	16.5	1.9	1.1	6.6
Area coefficient		1.5	1	1	1.5	1	1.5	2	1	1	1.5
Practicality score		4.5	1.5	2.7	5.3	3.5	4.1	5.6	2.3	3.0	4.5

management actions that will promote the continuation of oak-hickory forest. Other areas can be managed as time and money permit.

CONCLUSION AND FURTHER RESEARCH NEEDS

The 200 acre Lincoln Boyhood National Memorial has diverged greatly in vegetation structure and composition since 1816 as a result of man's actions. Upland, mesic mixed and bottomland hardwood forests were replaced by homesites, pastures, agricultural fields and secondary forests. In the process of change many exotic species were introduced. Neither the upland old growth forest nor the bottomland forest have survived without man leaving his mark. Yet these remnants are probably worth restoring because they are relatively intact. Greatly altered or anthropogenic communities will provide excellent opportunities for experimental restoration research, because the ramifications of mistakes will be less grave.

Resampling of the vegetation every 10 to 20 years will be critical in assessing the success of the restoration efforts. It is important that records be kept of management activities to evaluate why changes are occurring. This will prevent a lack of information as existed for the 1920-30's reforestation. Therefore, it is suggested that detailed records of activities such as tree, shrub, and herb planting and dead tree removal be kept. Crucial information will be when, where, and in what manner maintenance and management activities were performed. Preferably, the information should be accurately noted rather than from a plan of how it was going to be done. Thus when the next monitoring is performed, the researchers will be able to assess which changes are due to natural processes, and which are the result of management actions.

The resampling should be performed by one of the original researchers or in consultation with them, because this will reduce potential resampling errors that occur in such long-term studies (McCune and Menges 1986).

Important questions unaddressed in this report include: Are local herbivore populations affecting successional rates and trends in the vegetation. Is deer browsing so intense that it slows down succession? Can oak-hickory forest be maintained without infrequent fires? These may be decisive in determining the results of our efforts and may need to be addressed with further research.

We have illustrated here an approach and methodology to designing a natural vegetation restoration program based on historical records and current vegetation analyses. These provide a basis for management guidelines, goals and tentative experimental restoration methods. A more holistic approach would have incorporated information concerning the major animals affecting the structure and composition of the communities; however, this report is at least a starting point.

Throughout this report we have assumed that our goal is to approximate the presettlement vegetation, which will require intensive management. It is equally valid to allow the vegetation to change without any active, directed human intervention. Such a management decision ignores the intellectual and practical challenge of attempting to recreate an oak-hickory forest anew. We hope the challenges and trials of such an effort will not cause the future implementers of this plan, to pale from the task.

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APPENDICES

Appendix A. Dates of significant events in the history of the land that became the Lincoln Boyhood National Memorial.

Date	Significant Event
1804	Indiana Land Survey Office opened in Vincennes.
1805	David Sanford and Arthur Henri survey the land.
1816	Lincoln Family moves to Indiana.
Oct. 1817	Thomas Lincoln pays $16 as down payment on 160 acres.
Oct. 5, 1818	Nancy Hanks Lincoln died of milk sickness.
Dec. 2, 1819	Thomas Lincoln marries Sarah Bush Johnston.
April 28,1827	Thomas relinquishes east 80 acre tract to pay for the west 80 acre tract.
June 6, 1827	President John Quincy Adams signs patent giving Lincoln title to the west 80 acres.
Date unknown	Thomas Lincoln purchases 20 acres from David Casebier which permitted access to a spring for water.
Feb. 1830	Charles Grigsby purchases Lincoln's 100 acres.
March 1, 1830	Thomas Lincoln family moves to Illinois.
1865	John Rowbotham visits gravesite on thickly wooded hill.
Sept. 1865	William Herndon also visits gravesite, describes area.
1868	William Corbin visits site and composes poem about its deplorable condition.
Dec. 24, 1869	A committee forms to plan for marking the grave.
1870's	Town of Lincoln City is platted.
1870	John Armstrong erects marker on Nancy's grave.
1872-1875	Railroad tracks built through the area.
1879	Reporter writes of condition of site, as a result Mr. Studebaker donates marble marker and owner donates 1/2 acre.
1897	Benjamin B. Dale visits site and writes to Indiana governor about neglect. Nancy Hanks Lincoln Memorial Association is formed.
1900	Spencer County purchases 16 acres around the site.
Oct. 1, 1902	Stone slab erected from Abraham Lincoln's tomb.
1907	State overtakes maintenance of the site, Association is dissolved. Site is cleared of dead trees, underbrush and litter.
1917	Lincoln cabin site relocated, stone marker erected April 28.
1925	Governor installs commission to investigate establishing memorial. Ind. Lincoln Memorial Assoc. formed.
1926	Lieber requests landscape proposal from Frederick Law Olmsted, Jr.
Jan 24, 1927	Olmsted hired for preliminary plans.
May 7, 1927	Olmsted presents preliminary plans.
November 1929	State Park crews plant hardwoods at cabin site.
May 10, 1934	Cabin hearth stones discovered and excavated.
1927-1938	Structures removed from cabin site, reforestation, relocation of SR 162, construction of plaza and parking lot.

Appendix A. contd.

Date	Significant Event
1938-1944	Memorial Building constructed, South plaza landscaped, flagstaff relocated to its present position.
Fall 1963	Work crews remove underbrush and honeysuckle from the Memorial south of CR B. Area north of maintenance untouched.
1974-1976	"North Forty" acres north of CR B is acquired. Old homesites, sheds, etc. are removed. "North Forty" fields are abandoned.
Oct 1985	Hardwood Nursery Project started.
April 1986	Tree planting experiment initiated in old field.
June 1986	Honeysuckle and lawn grass removal experiments started.
June 1987	Herbaceous Plant Nursery initiated.
Fall 1987	Final tree planting and removal experiment sampling.

Appendix B. Summary of Ecological Characteristics of Trees found at Lincoln Boyhood National Memorial.

Species	Mast Freq.	Tolerance Shade	Tolerance Fire
Black oak-*Quercus velutina*	Biennial	Inter.	High
Blackjack oak-*Quercus marilandica*	Annual	Inter.	High
Burr oak-*Quercus macrocarpa*	Annual	Inter.	High
Chestnut oak-*Quercus muhlenbergii*	Annual	Low	Inter.
Pin oak-*Quercus palustris*	Biennial	Low	Low
Post oak-*Quercus stellata*	Annual	Low	High
Shingle oak-*Quercus imbricaria*	Annual	Low?	High?
White oak-*Quercus alba*	Annual	Inter.	Inter.
Bitternut hickory-*Carya cordiformis*	3-5 yrs.	Low	Low
Pignut hickory-*Carya glabra*	1-2 yrs.	Inter.	Low
Shagbark hickory-*Carya ovata*	1-3 yrs.	Inter.	Low
Sweet Pignut-*Carya ovalis*	1-3 yrs?	Inter?	Low?
Mockernut Hickory-*Carya tomentosa*	2-3 yrs.	Low	Low
Sugar maple-*Acer saccharum*	2-5 yrs.	High	Low
Red maple-*Acer rubrum*	Annual	High	Low
Tulip-tree-*Liriodendron tulipifera*	2-3 yrs?	Low	Inter.
Black gum-*Nyssa sylvatica*	2-3 yrs.?	Low	Low
Sweet gum-*Liquidambar styraciflua*	2-3 yrs.	Intol.	Low
Beech-*Fagus grandifolia*	2-3 yrs.	High	Low
Basswood-*Tilia americana*	Annual	High	Inter.
Red elm-*Ulmus rubrum*	2-4 yrs.	Inter.	
Rock elm-*Ulmus alata*		Low	
White ash-*Fraxinus americana*		Inter.	

Appendix B. contd.

Species	Mast Freq.	Tolerance Shade	Tolerance Fire
Green ash-*Fraxinus pennsylvanica*		Inter	
Dogwood-*Cornus florida*	2 yrs.	High	Low
PawPaw-*Asimina triloba*	3-5 yrs.?	Inter.?	Low?
Black walnut-*Juglans nigra*	3yrs.	Low	Inter.
Sycamore-*Platanus occidentalis*	1-2 yrs.	Inter.	Low
Sassafras-*Sassafras albidum*	1-2 yrs.	Low	Low
Red cedar-*Juniperus virginiana*	2-3 yrs.	Low	Low

APPENDIX C. Summary of herbaceous frequency by community and growth form.

TREE SEEDLINGS	LOWFIELD*	UPOFIELD	ABANHOME	BOTTSUCF	BOTTOMFO	MIXPLANT	UPSUCCFO	MESIHARD	UPHARDFO	SPUPHRDF
Sample size:	3	1	6	9	1	15	3	2	9	3
Acer rubrum L.	7.0	-	3.7	1.4	-	6.0	6.0	1.0	4.6	-
Acer saccharinum L.	-	-	-	0.2	-	2.7	0.3	-	1.7	-
Betula nigra L.	-	-	-	0.1	-	-	-	-	-	-
Carpinus caroliniana virginiana Fer		-	-	-	-	0.1	-	-	-	-
Carya cordiformis (Wang.) K. Koch		-	-	-	-	0.2	-	2.0	-	-
Carya glabra (Mill.) Sweet	-	-	-	-	-	-	0.3	-	-	-
Carya ovata (Mill.) K. Koch	-	-	-	-	-	0.2	0.3	-	-	-
Cornus florida L.	0.7	-	-	0.8	1.0	0.8	3.7	2.5	0.4	1.0
Fraxinus americana L.	0.3	-	0.3	0.4	-	1.9	1.3	0.5	1.8	0.3
Fraxinus sp.	-	-	0.2	1.0	-	2.3	3.3	3.0	1.0	-
Liquidambar styraciflua L.	-	-	0.2	0.2	-	0.5	-	-	-	-
Liriodendron tulipifera L. (E?)	-	-	0.2	0.1	-	0.5	-	-	-	-
Morus alba L.	-	-	-	-	-	-	-	-	0.1	-
Nyssa sylvatica Marsh.	-	-	-	-	-	0.1	-	-	0.1	-
Morus rubra L.	-	-	-	-	-	-	-	-	0.1	0.3
Prunus serotina Ehrh.	-	-	0.3	1.2	-	0.7	0.7	1.5	0.3	0.7
Quercus alba L.	-	-	-	-	-	-	-	-	-	0.3
Quercus imbricaria Michx.	0.3	1.0	0.2	0.1	-	-	-	-	-	-
Robinia pseudo-acacia L.	-	-	-	-	-	-	-	0.5	-	-
Sassafras albidum (Nutt.) Nees.	-	-	0.2	0.7	-	2.0	4.0	0.5	1.8	1.3
Ulmus rubrum Muhl.	0.3	-	0.7	0.4	-	0.4	0.3	2.0	0.6	1.0

SHRUBS	LOWFIELD*	UPOFIELD	ABANHOME	BOTTSUCF	BOTTOMFO	MIXPLANT	UPSUCCFO	MESIHARD	UPHARDFO	SPUPHRDF
Sample size:	3	1	6	9	1	15	3	2	9	3
Amelanchier sp.	-	-	-	0.1	-	-	-	-	-	-
Berberis thunbergii DC. (E)	-	-	0.2	-	-	-	-	-	-	-
Cercis canadensis L.	-	-	-	0.4	-	0.8	0.3	3.0	2.2	0.7
Celastrus scandens L.	-	-	-	-	-	0.1	-	-	0.1	-
Euonymus americana L.	-	-	-	-	-	0.1	1.0	0.5	0.2	-
Ligustrum vulgare L. (E)	-	-	-	-	-	0.5	0.3	-	-	-
Lindera benzoin (L.) Blume	-	-	-	0.2	1.0	0.3	-	-	0.7	-
Rhus copallina latifolia Engler	1.0	8.0	0.2	-	-	-	-	-	-	-
Sambucus canadensis L.	-	-	-	-	2.0	-	-	-	-	-
Ulmus alata Michx.	-	-	-	-	-	-	0.3	-	-	-
Viburnum dentatum L.	-	-	-	-	-	0.3	0.3	-	-	0.7
Viburnum prunifolium L.	-	-	-	-	-	1.0	-	0.5	0.1	-
Vinca minor L. (E)	-	-	-	-	-	-	-	-	2.0	-

VINE	LOWF* IELD	UPOF IELD	ABAN HOME	BOTT SUCF	BOTT OMFO	MIXP LANT	UPSU CCFO	MESI HARD	UPHA RDFO	SPUP HRDF
Sample size:	3	1	6	9	1	15	3	2	9	3
Campsis radicans (L.) Seem. ex Bureau	-	-	0.5	0.4	-	0.1	-	-	0.1	-
Clematis virginiana L.	-	-	0.2	0.9	1.0	-	-	-	-	-
Lonicera japonica Thunb. (E)	1.7	5.0	2.3	5.8	8.0	6.7	6.0	8.0	1.3	1.0
Menispermum canadense L.	-	-	0.2	-	-	-	-	-	-	0.3
Parthenocissus quinquefolia (L.) Planch.	2.3	-	1.0	4.6	7.0	4.0	4.7	7.5	8.1	5.3
Rhus radicans L.	0.3	1.0	1.0	2.7	5.0	2.5	3.0	3.5	1.2	8.7
Rubus sp.	0.3	6.0	2.8	1.7	4.0	0.3	-	2.0	0.8	-
Smilax sp.	1.3	-	0.2	0.9	1.0	0.8	0.7	1.0	0.3	0.3
Vitis sp	-	-	-	0.6	-	0.7	1.0	-	0.8	0.7

HERBS ANNUALS	LOWF* IELD	UPOF IELD	ABAN HOME	BOTT SUCF	BOTT OMFO	MIXP LANT	UPSU CCFO	MESI HARD	UPHA RDFO	SPUP HRDF
Sample size:	3	1	6	9	1	15	3	2	9	3
Acalypha rhomboidea Raf.	3.7	-	0.5	0.3	-	0.2	-	1.0	0.7	0.7
Ambrosia artemisiifolia L.	4.7	-	0.5	-	-	-	-	-	-	-
Ambrosia bidentata Michx.	0.3	-	-	-	-	-	-	-	-	-
Amphicarpa bracteata (L.) Fern.	2.3	-	0.2	0.1	-	0.1	-	-	0.4	-
Bidens aristosa (Michx.) Britt.	0.7	6.0	1.5	-	-	-	-	-	-	-
Bromus racemosus L. (E)	1.0	-	0.3	-	-	0.1	-	-	-	0.7
Cassia fasciculata	2.3	2.0	1.8	-	-	-	-	-	-	-
Cirsium sp. (E)	1.3	-	0.2	-	-	-	-	-	-	-
Commelina communis L. (E)	-	-	0.8	0.3	-	-	-	-	-	-
Digitaria sanguinalis (L.) Scop. (E)		-	0.2	0.6	-	-	-	-	0.1	-
Diodia teres Walt.	4.7	2.0	-	-	-	-	-	-	-	-
Galium aparine L.	-	-	-	0.4	4.0	-	-	-	-	-
Impatiens capensis Meerb.	-	-	0.2	1.3	3.0	0.6	-	0.5	-	-
Rumex acetosella L. (E)	-	-	-	0.1	-	-	-	-	-	-
Trifolium dubium Sibth. (E)	-	-	0.2	-	-	-	-	-	-	-

BIENNIALS	LOWF* IELD	UPOF IELD	ABAN HOME	BOTT SUCF	BOTT OMFO	MIXP LANT	UPSU CCFO	MESI HARD	UPHA RDFO	SPUP HRDF
Sample size:	3	1	6	9	1	15	3	2	9	3
Daucus carota L. (E)	0.7	1.0	1.8	-	-	-	-	-	-	-
Melilotus alba Desr. (E)	-	-	0.7	-	-	-	-	-	-	-
Oenothera biennis L. (E)	1.3	-	0.5	-	-	-	-	-	-	-

PERENNIALS	LOWF*IELD	UPOFIELD	ABANHOME	BOTTSUCF	BOTTOMFO	MIXPLANT	UPSUCCFO	MESIHARD	UPHARDFO	SPUPHRDF
Sample size:	3	1	6	9	1	15	3	2	9	3
Achillea millefolium L.	-	1.0	-	-	-	-	-	-	-	-
Agrimonia sp.	-	-	-	-	-	-	0.3	-	-	-
Andropogon virginicus L.	2.0	1.0	-	-	-	-	-	-	-	-
Apocynum sp.	0.3	-	0.2	0.1	-	-	-	-	-	-
Artemisia ludoviciana Nutt.	-	-	0.5	-	-	-	-	-	-	-
Aster sp.	0.3	-	0.7	0.6	2.0	0.1	-	0.5	0.1	0.3
Boehmeria cylindrica (L.) Sw.	-	-	0.2	0.7	-	-	-	-	-	-
Boltonia asteroides (L.) L'Her	-	-	0.3	-	-	-	-	-	-	-
Carex annectatans Bickn.	-	-	0.2	0.3	-	-	-	-	-	-
Carex complinatum Torr & Hook	0.7	-	-	0.1	-	-	-	-	-	-
Cynoglossum virginainum L.	-	-	-	0.3	-	0.1	-	-	-	-
Carex 2	0.7	7.0	0.2	0.2	-	-	-	-	-	-
Brasicaceae sp	-	-	0.2	-	-	-	-	-	-	-
Carex A	-	-	-	0.1	4.0	0.3	-	1.5	0.4	1.0
Carex B	-	-	-	-	4.0	0.4	1.0	0.5	0.4	0.3
Carex C	-	-	-	0.6	4.0	0.1	-	1.0	0.4	0.3
Dactylis glomerata L. (E)	-	-	1.3	-	-	-	-	-	-	-
Danthonia spicata (L.) Beauv.	-	6.0	-	-	-	-	-	-	-	-
Desmodium paniculatum (L.) DC	2.0	3.0	1.2	0.2	-	-	-	-	-	-
Elymus virginicus L.	-	-	-	1.9	8.0	-	-	-	-	-
Erigeron sp.	0.7	-	0.7	0.1	-	-	-	-	-	-
Eupatorium coelostinum L.	-	-	-	0.1	-	-	-	-	-	-
Eupatorium hyssopifolium L.	4.7	-	-	-	-	-	-	-	-	-
Eupatorium perfoliatum L.	-	-	0.2	-	-	-	-	-	-	-
Eupatorium rugosum Houtt.	-	-	-	0.3	-	0.3	-	6.5	0.2	0.7
Eupatorium serotinum Michx.	-	-	0.5	0.2	-	-	-	-	-	-
Euphorbia sp	0.3	-	-	-	-	-	-	-	-	-
Festuca elatior L. (E)	-	-	5.2	0.1	-	0.3	-	-	-	-
Galium circeazans Michx.	-	-	-	0.6	-	1.3	3.0	1.0	1.2	1.0
Galium pilosum Ait.	-	-	-	0.1	-	-	-	0.5	-	-
Galium trifidum L.	-	-	0.5	0.7	-	0.4	0.7	1.5	0.3	0.3
Galium sp.	-	-	0.2	-	-	-	-	-	-	-
Geum spp.	-	-	1.3	1.3	7.0	0.5	-	2.5	0.1	-
Glyceria sp.	-	-	0.2	0.9	-	-	-	-	-	-
Hackelia virginiana (L.) I.M. Johnson	-	-	-	-	-	0.1	-	-	0.1	-
Hypericum canadense L.	1.0	1.0	0.8	-	-	-	-	-	-	-
Hypericum denticulatum Walt.	0.3	-	0.2	0.2	-	-	-	-	-	-
Hypericum sp.	-	-	-	0.1	-	0.1	0.3	-	-	-
Hypericum sp 2.	-	-	0.2	-	-	-	-	-	-	-
Juncus sp.	2.3	1.0	1.5	-	-	-	-	-	-	-
Leersia virginica Willd.	-	-	-	0.3	1.0	-	-	-	-	-
Lespedeza sp.	-	2.0	-	-	-	-	-	-	-	-
Linear leaved fuzzy	-	-	0.3	-	-	-	-	-	-	-
Lobelia inflata L.	0.7	1.0	0.2	0.2	-	0.1	-	-	-	-
Ludwigia alternifolia L.	-	-	0.2	-	-	-	-	-	-	-
Milky saggitate leave	-	-	0.2	-	-	-	-	-	-	-
Moss	-	-	0.2	0.2	-	0.3	-	-	-	-

PERENNIALS contd.	LOWFIELD	*UPOFIELD	ABANHOME	BOTTSUCF	BOTTOMFO	MIXPLANT	UPSUCCFO	MESIHARD	UPHARDFO	SPUPHRDF
Oxalis europaea Jord.	-	-	0.2	0.3	-	0.1	-	0.5	0.1	-
Oxalis stricta L.	0.3	-	-	-	-	-	0.3	1.0	0.2	-
Panicum lanuginosum Ell.	3.3	4.0	1.0	1.2	-	-	-	-	-	-
Panicum latifolium L.	-	-	0.2	0.1	-	-	-	-	-	-
Panicum spp.	2.3	-	-	-	-	-	0.3	-	-	-
Phryma leptostachya L.	-	-	-	-	-	0.1	-	-	0.2	0.7
Phytolacca americana L.	1.0	-	-	0.7	-	0.3	-	-	0.1	0.7
Pilea pumila (L.) Gray	-	-	0.3	0.7	9.0	0.6	-	0.5	0.8	0.3
Plantago major L. (E)	-	-	1.5	-	-	-	-	-	-	-
Poa compressa L.	-	-	0.3	-	-	-	-	-	-	-
Poa spp. (E)	-	-	1.3	0.2	-	-	-	-	-	-
Polygala sanguinea L.	0.3	-	-	-	-	-	-	-	-	-
Polygonum spp.	-	-	0.3	0.1	-	-	-	-	-	-
Potentilla simplex Michx.	1.3	4.0	0.2	-	-	-	-	-	0.4	-
Prenanthes sp.	-	-	-	0.1	-	-	-	-	-	-
Prunella vulgaris lanceolata (Bart.)Fern			0.7	-	-	-	0.3	-	-	-
Pycnanthemum tenuifolium Schrad.	0.3	5.0	1.7	-	-	-	-	-	-	-
Ranunculus sp.	-	-	-	0.1	-	0.1	-	-	-	-
Sanicula canadensis L.	-	-	-	0.8	1.0	1.2	2.3	0.5	0.4	0.3
Scirpus atrovirens georgianus Harper	0.3	-	-	0.2	-	-	-	-	-	-
Setaria geniculata (Lam) Beauv.	0.3	-	0.7	-	-	-	-	-	-	-
Solanum carolinense L. (E)	0.7	-	0.5	0.2	-	-	-	-	-	-
Solidago altissima L.	9.3	-	6.5	0.7	-	-	-	-	-	-
Solidago graminifolia media	1.7	2.0	1.2	0.1	-	-	-	-	-	-
Solidago juncea Ait.	0.7	-	-	-	-	-	-	-	-	-
Solidago nemoralis Ait.	5.3	10.0	0.2	-	-	-	-	-	-	-
Taraxacum officinale Weber (E)	0.3	-	0.3	0.1	-	-	-	-	-	-
Tovara virginiana (L.) Raf.	-	-	0.2	-	-	-	-	2.0	0.1	0.7
Trifolium repens L. (E)	-	-	0.2	-	-	-	-	-	-	-
Uniola latifolia Michx.	-	-	-	-	-	-	0.3	-	-	-
Vernonia altissima Nutt.	-	-	0.2	0.1	-	-	-	0.5	-	-
Viola papilionacea Pursh	-	-	-	0.2	5.0	0.7	-	-	0.3	0.3
Unknown grass	-	6.0	1.0	0.1	-	-	-	-	-	1.0
Unknown seedling	-	-	-	-	-	0.1	-	-	-	-

SPRING EPHEMERALS	LOWFIELD	*UPOFIELD	ABANHOME	BOTTSUCF	BOTTOMFO	MIXPLANT	UPSUCCFO	MESIHARD	UPHARDFO	SPUPHRDF
Sample size:	3	1	6	9	1	15	3	2	9	3
Allium sp.	0.7	-	0.2	0.3	2.0	1.2	0.3	7.5	0.1	-
Anemonella thalictroides (L.) Spach		-	-	-	-	-	-	-	0.2	-
Arisaema atrorubens (Ait.) Blume	-	-	-	-	-	-	0.3	0.5	0.2	0.7
Cardamine douglassii (Torr) Britt.		-	-	-	1.0	-	-	-	-	-
Claytonia virginica L.	-	-	-	-	-	0.1	-	7.5	2.0	4.7
Cryptotaenia canadensis (L.) DC.	-	-	-	0.2	-	0.6	1.3	-	0.1	-
Dentaria laciniata Muhl.	-	-	-	-	-	0.1	0.7	4.0	2.0	8.3
Erythronium americanum Ker.	-	-	-	-	-	-	-	1.5	0.2	-

SPRING EPHEMERALS contd.	LOWF*	UPOF	ABAN	BOTT	BOTT	MIXP	UPSU	MESI	UPHA	SPUP
	IELD	IELD	HOME	SUCF	OMFO	LANT	CCFO	HARD	RDFO	HRDF
Geranium maculatum L.	-	-	-	0.2	1.0	0.7	0.3	-	0.1	-
Mitella diphylla L.	-	-	-	-	-	0.1	-	-	-	-
Oxalis violacea L.	-	-	-	-	-	-	-	-	0.1	-
Phacelia bipinnatifida Michx.	-	-	-	0.6	6.0	0.3	0.3	2.5	0.2	0.3
Podophyllum peltatum L.	-	-	-	0.1	-	-	-	-	-	2.7
Polygonatum biflorum (Walt.) Ell.	-	-	-	-	-	-	-	-	0.1	-
Trillium recurvatum Beck	-	-	-	-	-	-	-	-	-	0.3
Viola papilionacea Pursh	-	-	-	0.2	5.0	0.7	-	-	0.3	0.3
Viola pensylvanica Michx.	-	-	-	-	-	-	-	-	0.2	-
Viola striata Ait.	-	-	-	-	6.0	-	-	-	0.1	-

FERNS AND FERN ALLIES	LOWF*	UPOF	ABAN	BOTT	BOTT	MIXP	UPSU	MESI	UPHA	SPUP
	IELD	IELD	HOME	SUCF	OMFO	LANT	CCFO	HARD	RDFO	HRDF
Sample size:	3	1	6	9	1	15	3	2	9	3
Asplenium platyneuron (L.) Oakes	-	1.0	0.2	0.3	-	0.5	1.0	0.5	-	-
Botrychium dissectum Spreng.										
tenuifolium (Underw.) Farw.	-	-	0.2	0.3	-	0.1	-	0.5	-	-
Botrychium dissectum Spreng.	-	-	-	-	-	0.1	-	-	-	-
Botrychium virginianum (Lam) SW	-	-	-	0.2	-	1.1	1.3	1.0	-	-
Lycopodium complanatum L.										
flabelliforme Fern.	-	-	-	-	-	0.1	-	-	-	-
Onoclea sensiblis L.	-	-	0.2	0.1	-	-	-	-	-	-

APPENDIX D. Summary of community changes in management experiments.

TABLE D1 - Harrison Street Honeysuckle Removal Experiment.

TABLE D2 - Old Field Honeysuckle Removal Experiment.

TABLE D3 - Nonnative Lawn Grass Removal Experiment.

Table D1. Summary of trends in mean cover by species for the Harrison St. Japanese honeysuckle removal experiment.

	TREATMENT							
	CONTROL				HERBICIDE			
DATE:	6/86	9/86	6/87	9/87	6/86	9/86	6/87	9/87
Acer saccharum Marsh.	6.33	9.67	4.75	9.75	20.00	2.20	1.00	.25
Asplenium platyneuron								
(L.) Oakes	1.33	1.67	2.00	1.75	1.00	.80	-	-
Botrychium sp	.33	.33	-	-	.40	.40	-	-
Carex sp	-	.33	-	.25	3.20	.60	-	-
Carya sp	1.00	-	-	-	1.40	1.20	-	-
Cercis canadensis L.	-	-	-	-	-	-	-	.25
Cornus florida L.	1.67	-	1.50	-	-	1.40	-	-
Fraxinus sp	-	-	-	-	.40	-	-	-
Galium pilosum Ait.	-	-	-	-	.40	-	-	-
Lonicera japonica Thunb.	36.67	30.00	26.25	8.00	37.00	5.60	.50	.50
Parthenocissus quinquefolia (L.)								
Planch	4.33	.33	2.25	-	3.00	-	.25	-
Rhus radicans L.	-	.33	.75	-	7.00	.20	.25	-
Geum sp	-	.33	.75	-	-	.20	.25	-
Sassafras albidum	-	-	-	-	-	-	-	-
(Nutt.) Nees.	.33	3.00	1.50	1.50	5.20	.20	2.50	2.00
Ulmus rubra	-	.33	-	-	-	-	-	.25
unknown	-	-	-	-	.20	.20	-	-
Urtica dioica L.	1.33	-	-	-	.20	-	-	-
Viburnum prunifolium L.	1.00	8.33	5.75	-	-	-	-	-
Viola papilionacea Pursh	.67	-	.25	-	.80	-	.25	-
Viola pensylvanic Michx.	.33	-	.50	-	.40	-	.25	-
Total forbs	4.00	2.67	3.50	2.00	6.60	2.20	.75	-
Woody plants	14.67	22.00	16.50	11.25	37.00	5.20	4.00	3.75

Table D2. Summary of trends in mean cover by species for the old field Japanese honeysuckle removal experiment.

	TREATMENT															
	AUTUMNAL HERBICIDE				CONTROL				HAND REMOVAL				VERNAL HERBICIDE			
DATE:	6/86	9/86	6/87	9/87	6/86	9/86	6/87	9/87	6/86	9/86	6/87	9/87	6/86	9/86	6/87	9/87
Acalypha rhomboidea Raf.	-	-	-	1.50	-	-	-	.25	-	1.00	-	-	-	-	-	1.25
Acer rubrum L.	22.00	14.25	13.00	15.75	37.00	37.25	37.50	19.75	17.50	9.50	10.00	17.50	12.50	1.75	8.75	3.00
Allium sp	-	-	.50	-	-	-	-	-	-	-	1.00	-	-	-	.50	-
Ambrosia artemisifolia L.	.25	.50	2.75	-	.50	.75	.75	-	.50	5.00	-	-	.25	-	.25	5.00
Andropogon virginicus L.	-	-	-	-	-	-	-	-	-	-	-	2.50	-	-	-	-
Bidens aristosa (Michx.) Britt.	-	-	-	1.00	-	.50	-	-	-	1.50	1.00	4.50	-	-	-	3.75
Cacalia sp	-	-	-	-	-	2.50	-	-	-	3.50	-	-	-	-	-	-
Cassia fasciculata Michx.	1.00	7.50	2.50	-	1.00	5.00	.50	-	1.50	5.00	6.00	-	.50	-	1.25	-
Convolvulus sp	2.00	.25	4.75	.75	-	2.00	2.00	-	2.50	4.00	3.50	-	3.50	5.75	2.75	-
Cornus florida L.	-	-	-	-	-	.50	-	1.25	-	-	-	-	-	-	-	-
Dactylus glomerata L.	-	-	.75	-	-	-	-	-	-	-	-	-	-	-	-	-
Desmodium sp	2.00	5.00	.50	1.50	.50	2.50	4.50	3.50	-	-	.50	-	1.50	-	-	-
Digitaria sanguinalis (L.) Scop.	-	-	1.25	316.25	-	-	-	-	-	30.00	60.00	92.50	-	.50	6.25	12.00
Diodia teres Walt.	-	-	1.25	1.25	-	-	-	-	-	2.00	1.50	1.50	-	-	-	1.25
Diospyros virginiana L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Erigeron canadensis L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-
Erigeron strigosus Muhl.	-	-	-	-	-	-	-	-	-	-	2.00	-	-	-	.75	-
Eupatorium perfoliatum L.	-	.50	-	.25	-	3.75	-	-	-	2.50	3.00	2.00	-	-	-	-
Fraxinus sp	.50	-	-	-	-	-	.50	-	-	-	-	-	-	-	-	-
Geranium carolinianum L.	-	-	-	-	-	-	-	-	-	-	1.50	-	-	-	-	-
Gerardia sp	-	-	-	1.25	-	1.25	-	.25	-	1.00	10.00	3.50	-	-	-	11.75
Hieracium sp	-	-	-	-	-	-	-	-	-	-	-	-	-	.25	-	-
Impatiens sp	-	.25	1.25	-	-	-	-	-	-	-	-	-	-	-	-	-
Ipomoea sp	-	-	-	-	-	-	-	-	-	1.50	-	-	-	.75	-	-
Kuhnia eupatoroides L.	-	-	-	-	-	-	-	1.00	-	-	-	4.00	-	-	-	-
Lactuca sp	-	-	-	-	-	-	-	-	-	-	-	-	-	.25	1.25	.25
Liriodendron tulipifera L.	-	-	-	-	.75	1.25	1.25	1.00L.	-	-	-	-	-	-	-	-
Liquidambar styraciflua L.	8.75	18.75	20.00	17.50	-	-	-	- L.	-	-	-	-	1.25	-	-	-
Lonicera japonica L.	81.25	90.00	4.75	16.25	78.75	91.25	70.00	81.25	75.00	4.50	12.00	3.50	80.00	8.25	16.00	39.25
Ludwigia alternifolia L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.25

Table D2 contd.

	TREATMENT															
	AUTUMNAL HERBICIDE				CONTROL				HAND REMOVAL				VERNAL HERBICIDE			
DATE:	6/86	9/86	6/87	9/87	6/86	9/86	6/87	9/87	6/86	9/86	6/87	9/87	6/86	9/86	6/87	9/87
Oxalis stricta L.	-	-	.50	-	-	-	-	-	-	-	-	-	-	-	.75	4.00
Panicum lanuginosum Ell.	-	-	-	-	-	-	-	-	.50	-	6.00	-	-	-	1.25	2.50
Parthenocissus quinquefolia (L.) Planch.	.25	.25	-	-	-	-	-	-	-	-	2.50	-	-	-	1.00	-
Plantago major L.	-	-	1.25	-	-	-	-	-	-	-	-	-	-	-	4.50	-
Poa sp	-	-	.75	-	-	-	-	-	-	-	-	-	-	-	2.50	-
Polygala sanguinea L.	-	-	.75	-	-	-	-	-	-	-	-	-	-	-	.75	-
Prunus serotina Ehrh.	-	.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pycnanthemum tenuifolium Shrad.	2.50	5.00	-	-	1.25	1.25	1.25	.25	.50	1.50	2.00	1.50	1.25	-	1.75	.50
Quercus rubra L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.75
Rubus sp	-	-	-	2.00	.75	1.00	1.00	-	-	-	-	-	-	-	-	-
Sabatia angularis (L.) Pursh.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.75	-
Setaria geniculata (Lam.) Beauv.	-	-	-	3.00	-	-	-	-	-	-	-	-	-	-	-	2.50
Solanum carolinense L.	-	-	-	-	.75	1.75	-	-	-	-	-	-	-	.25	.50	-
Solidago altissima L.	10.75	13.00	3.75	2.00	8.75	13.75	13.00	11.00	19.00	7.00	6.50	20.00	17.50	1.25	8.25	7.00
Solidago nemoralis Ait.	.75	.50	-	1.00	-	-	-	.50	-	.50	-	-	-	-	-	-
Solidago juncea Ait.	9.00	8.00	6.75	12.00	15.00	6.25	10.00	6.25	27.50	22.50	9.00	7.00	3.25	-	6.25	4.00
Solidago graminifolia														-	-	-
(L.) Salisb.	-	.75	1.00	3.75	1.25	-	-	-	-	-	2.50	2.50	1.25	1.25	-	.75
Stellaria sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.50	-
Taraxacum officinale Weber	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.75
Trifolium sp.	-	-	-	-	-	.50	-	-	-	-	-	-	-	-	-	-
Ulmus rubra Muhl.	-	-	-	.25	1.75	-	-	-	-	.50	-	-	-	-	-	-
unknown	-	-	-	-	.50	-	-	-	.50	-	-	-	-	-	.50	-
Total forbs	28.25	41.25	27.50	26.25	29.50	41.75	32.00	23.00	52.00	58.50	50.00	46.50	29.00	9.75	33.25	41.50
Woody stems	31.50	33.50	33.00	35.50	40.25	40.00	40.25	22.00	17.50	10.00	12.50	17.50	13.75	1.75	9.75	3.75
Grass total	-	-	2.75	19.25	-	-	-	-	.50	30.00	66.00	95.00	-	.50	10.00	17.35

Table D3. Summary of the trends in the nonnative lawn grass removal experiment.

	TREATMENT											
	HERBICIDE				HERBICIDE+RAKE				CONTROL			
DATE:	6/86	9/86	6/87	9/87	6/86	9/86	6/87	9/87	6/86	9/86	6/87	9/87
Acalypha rhomboidea Raf.	-	-	1.67	2.17	-	-	1.67	1.83	.3	-	.17	-
Acer rubrum L.	.17	-	-	-	-	-	-	-	-	-	-	-
Allium sp	.50	.17	2.00	.50	-	-	.8	-	-	-	.17	-
Ambrosia artemisifolia L.	6.50	-	3.8	5.17	2.50	-	12.00	16.50	.3	-	.50	.50
Ambrosia trifida L.	-	-	-	-	-	-	.17	-	-	-	-	-
Artemisia ludoviciana Nutt.	.3	-	-	-	-	-	-	-	.67	.17	-	-
Aster sp 1	-	-	.17	-	-	-	.17	.33	-	.17	-	-
Aster sp 2	-	-	-	-	-	-	-	.17	-	-	-	-
Bidens aristosa (Michx.) Britt.	-	-	6.50	6.17	-	-	2.3	2.50	-	.67	-	.33
Brassica sp	-	-	-	-	-	-	.50	-	-	-	-	-
Bromus sp	-	-	-	-	-	-	1.17	-	-	-	-	-
Bromus racemosus L.	-	-	-	-	4.17	-	4.00	-	-	-	-	-
Carex sp	-	-	-	-	-	-	-	-	.17	-	-	-
Circium sp	-	-	-	.50	-	-	1.67	.83	-	-	-	-
Convolvulus sp	-	-	-	-	-	-	.17	-	-	-	-	-
Cornus florida L.	-	-	-	-	-	-	-	-	-	-	.50	.17
Dactylus glomerata L.	3.67	-	.8	.50	2.50	-	2.17	1.17	1.3	-	1.17	.83
Daucus carota L.	1.17	.17	2.50	1.3	1.00	.17	4.00	1.83	.3	.67	.50	.67
Desmodium sp	1.17	.17	-	-	.8	.17	.50	-	.3	.17	-	-
Digitaria sanguinalis (L.) Scop.	-	-	.8	2.00	-	-	.8	.67	-	-	-	-
Erigeron strigosus Muhl.	-	-	.67	1.3	-	-	1.00	-	-	-	-	-
Eupatorium serotinum Michx.	-	.17	2.3	4.67	.17	-	1.3	8.33	.3	-	-	-
Euphorbia sp	-	-	-	.17	-	.3	-	.50	-	-	-	-
Festuca sp	84.17	1.33	28.33	43.83	74.17	-	17.00	20.83	87.50	92.50	89.17	97.00
Gerardia sp	-	-	-	-	-	-	-	1.00	-	-	-	-
Glechoma hederacea L.	-	-	.17	-	-	-	-	-	-	-	-	-
Gnaphalium sp	-	-	.17	.3	.50	-	-	.17	-	-	-	-
Heuchera sp	-	-	.50	.67	-	-	-	-	-	-	-	-
Lactuca sp	-	-	.8	-	-	-	.50	.33	-	-	-	-
Liquidambar styraciflua L.	-	-	-	-	.17	-	-	-	-	-	-	-

Table D3 contd.

	TREATMENT											
	HERBICIDE				HERBICIDE+RAKE				CONTROL			
DATE:	6/86	9/86	6/87	9/87	6/86	9/86	6/87	9/87	6/86	9/86	6/87	9/87
Liriodendron tulipifera L.	-	-	.3	-	-	-	-	-	-	.17	-	-
Melilotus alba Desr.	-	-	1.3	-	-	-	-	-	-	-	-	-
Oenothera biennis L.	-	-	.17	-	-	-	.8	-	-	-	-	-
Oxalis stricta L.	-	-	.50	.8	-	.17	.67	1.17	-	-	-	-
Panicum lanuginosum Ell.	-	-	-	-	-	-	-	1.33	-	-	-	-
Parthenocissus quinquefolia (L.) Planch.	1.00	.50	5.8	.17	.3	-	-	.17	.50	.3	.67	.17
Phleum pratense L.	-	-	.17	-	-	-	.8	.33	-	-	.3	-
Plantago lanceolata L.	-	-	.3	.3	-	-	1.3	-	-	-	-	-
Plantago major L.	-	.17	2.8	.67	-	-	2.67	.83	-	-	-	-
Poa compressa L.	-	-	-	.3	-	-	-	7.50	-	-	-	-
Poa sp	-	-	-	-	.67	-	-	-	-	-	-	-
Polygonum sp	-	-	.17	-	-	-	-	-	-	-	-	-
Prunella vulgaris L.	-	-	-	.67	-	-	-	.83	.3	.3	-	-
Prunus serotina Ehrh.	-	-	-	-	.3	-	-	-	-	-	.17	.17
Pycnanthemum tenuifolium Schrad.	-	-	.17	.17	.50	-	.67	.17	-	-	.17	-
Rhus copallina L.	-	-	-	-	.17	-	1.17	4.17	-	-	-	-
Rhus radicans L.	-	-	-	.17	-	-	-	-	-	-	-	-
Rosa sp	.17	-	-	-	-	-	-	-	-	-	-	-
Rubus sp	-	-	.8	.3	-	-	.17	-	-	-	-	-
Sassafras albidum (Nutt.) Nees.	-	-	-	-	-	-	.67	.17	-	-	-	-
Senecio sp	-	-	.8	.17	-	-	-	.33	-	-	-	-
Setaria geniculata (Lam.) Beauv.	-	-	-	4.50	-	-	-	-	-	-	-	-
Solidago altissima L.	1.00	-	1.17	4.17	1.67	-	.50	.17	1.8	.8	3.3	5.00
Solidago graminifolia (L.) Salisb.	-	-	-	-	-	-	-	.67	.50	.8	1.67	.83
Solidago nemoralis Ait.	.67	-	-	-	7.3	-	2.00	3.67	-	-	-	-
Taraxacum officinale Weber	-	-	.3	.17	-	-	.17	.17	-	-	-	-
Trifolium procumbens L.	1.17	-	4.8	-	2.50	-	7.67	1.50	.3	-	-	-

Table D3 contd.

	TREATMENT											
	HERBICIDE				HERBICIDE+RAKE				CONTROL			
DATE:	6/86	9/86	6/87	9/87	6/86	9/86	6/87	9/87	6/86	9/86	6/87	9/87
<u>Trifolium</u> <u>repens</u> L.	-	-	.3	-	-	-	6.00	-	-	-	-	-
<u>Ulmus</u> <u>americana</u> L.	.3	-	.17	-	.3	-	-	-	.67	.17	.3	.33
unknown grass 1	-	.3	-	-	-	1.17	-	-	-	-	-	-
unknown grass 2	-	-	-	1.50	-	-	-	.33	-	-	-	-
<u>Vitis</u> sp	-	-	-	-	-	-	.17	.33	-	-	-	-
<u>Vulpia</u> <u>octoflora</u> (Walt.) Rhydb.	-	-	-	-	-	-	.3	-	-	-	-	-
seedlings	-	-	1.3	-	.17	-	5.00	-	.3	-	-	-
unknown sp	.8	.17	.8	.3	-	-	.50	-	.17	-	-	.17
Total forbs	12.17	1.00	31.67	30.50	14.67	.83	47.17	42.33	5.3	4.17	6.3	7.67
Woody stems	.67	-	.50	-	.8	-	2.00	4.67	.67	.3	1.00	.67
Grass total	87.8	1.67	30.17	52.33	80.8	1.17	26.00	23.33	88.83	92.50	90.67	97.83

APPENDIX E. Layout of sampling and experimental plots.

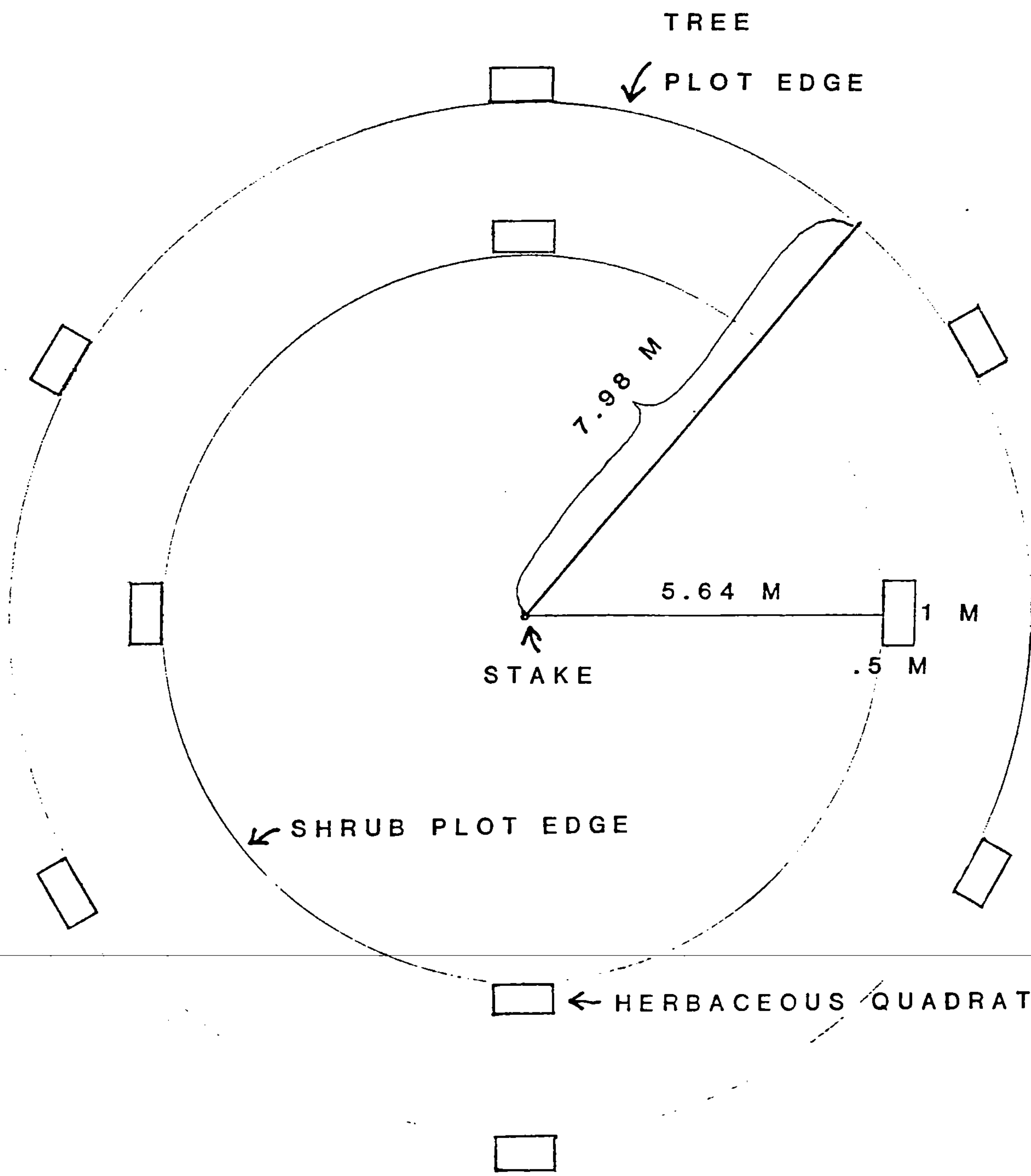

Figure E1. Arrangement of the permanent circular plotssetup at Lincoln Boyhood National Memorial.

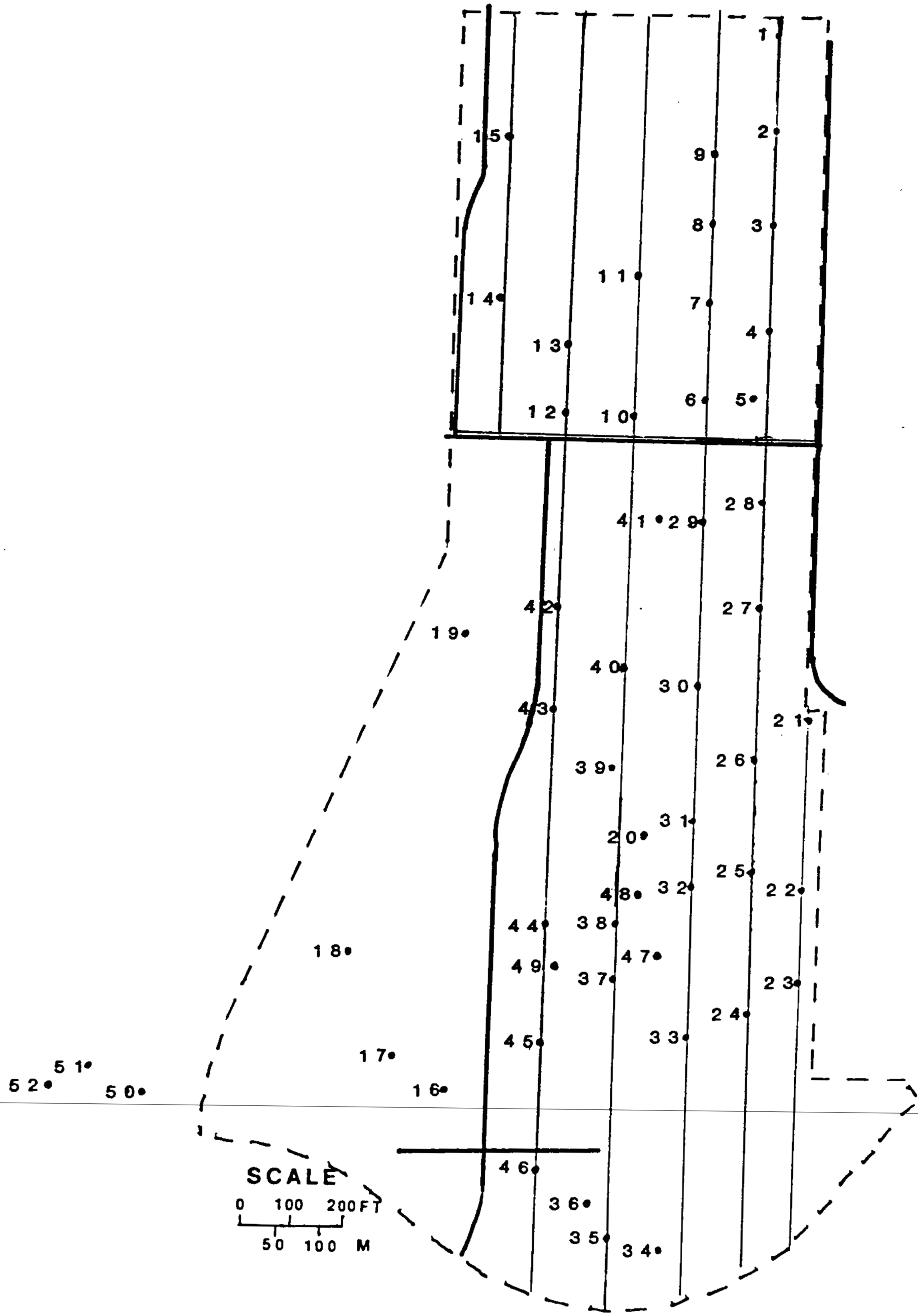

Figure E2. Locations of the permanent circular plots at Lincoln Boyhood National Memorial.

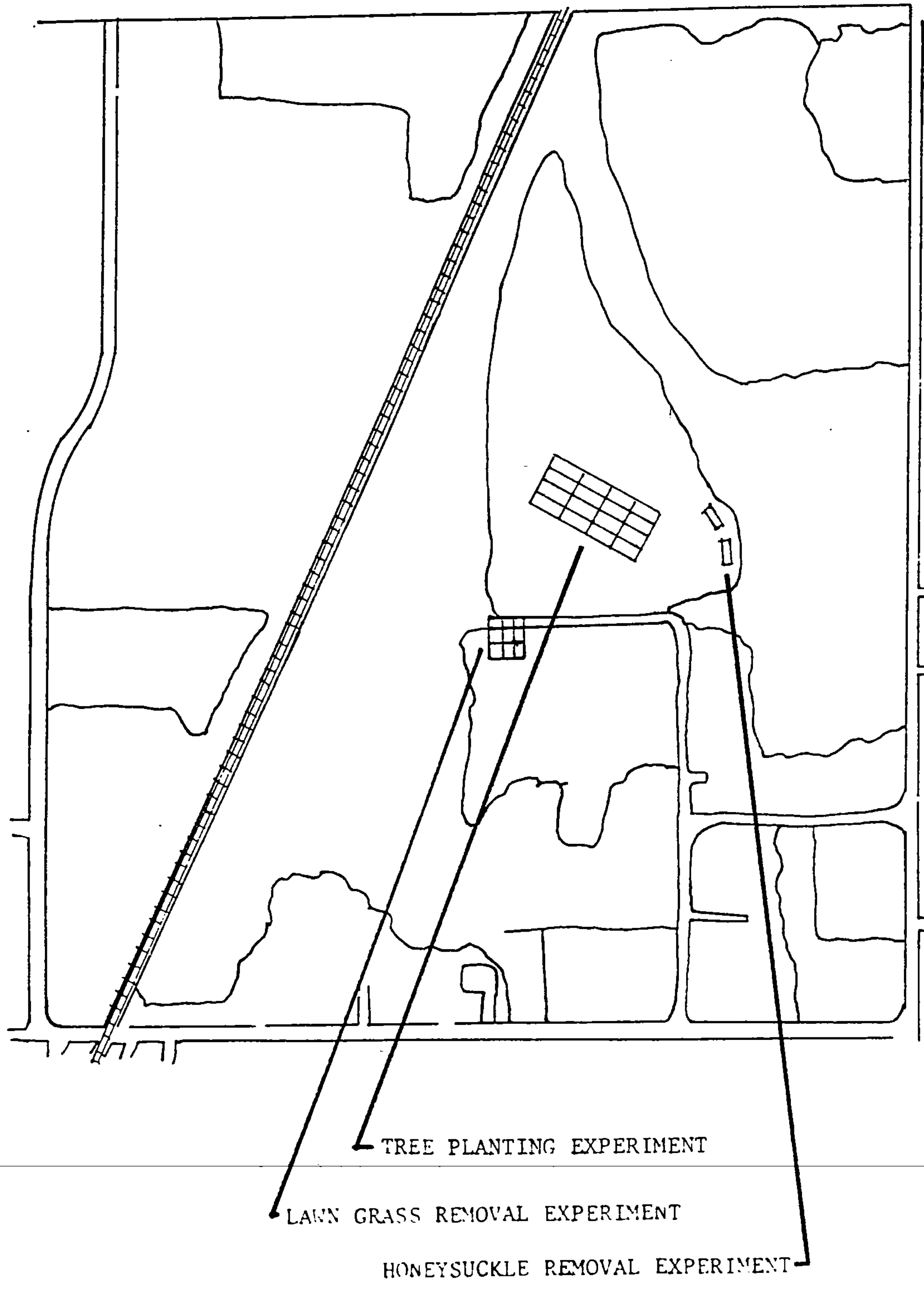

Figure E3. Locations for management research plots at Lincoln Boyhood National Memorial.

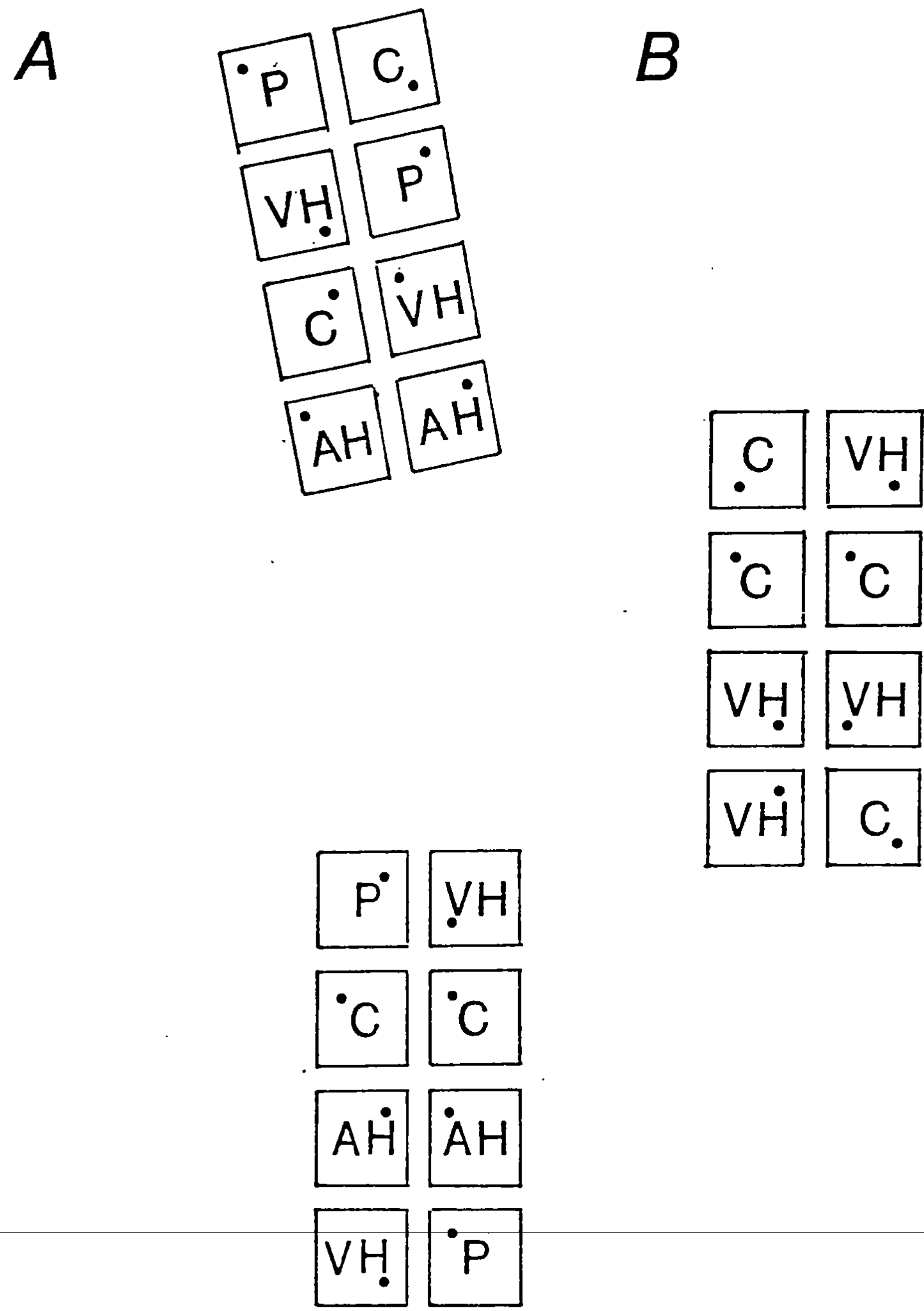

Figure E4. Layout of the Japanese honeysuckle removal experiment plots. A= Old field site. B= Harrison St. site. C= control, P= pull up, VH= vernal herbicide, and AH= autumnal herbicide.

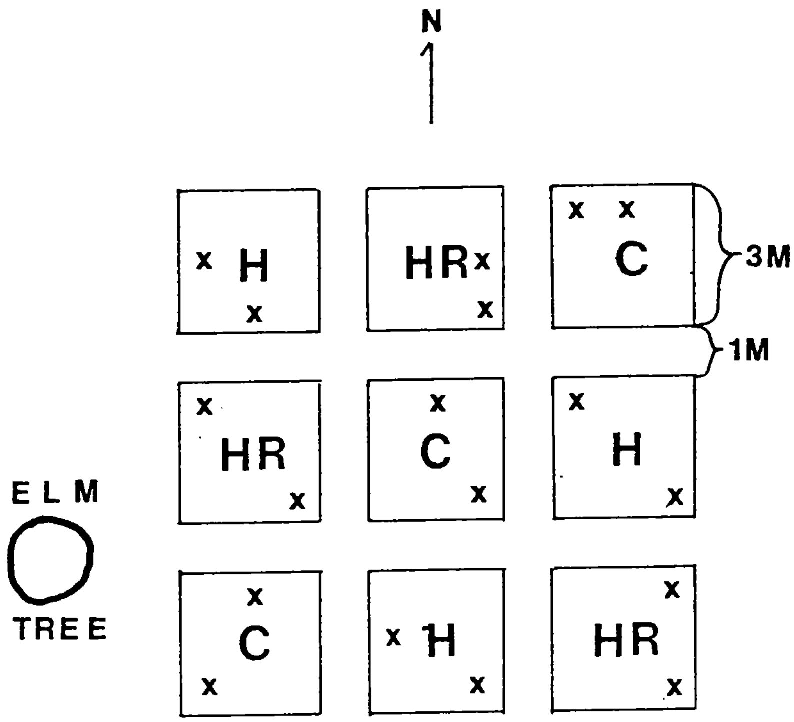

Figure E5. Layout of the exotic grass removal experiment. C = control, H = herbicide, HR = Herbicide + raking or the litter, and X = 1 M sq. subsample that was sampled.

DESIGN OF FOREST RESTORATION EXPERIMENT AT LINCOLN BOYHOOD NATIONAL MEMORIAL

A complete randomized block design of 10 m by 15 m plots was used. Plots are marked with color coded electrical conduit at all four corners. The treatments and color codes are as shown below. Ten each of pin, white, and black oak trees were randomly planted in each plot except the control.

CONTROL (unpainted) - no treatment.
PLANTED (yellow) - planted only.
MOWED (red) - mowed to soil and planted.
REMOVED (white) - planted and all red maples removed.

N

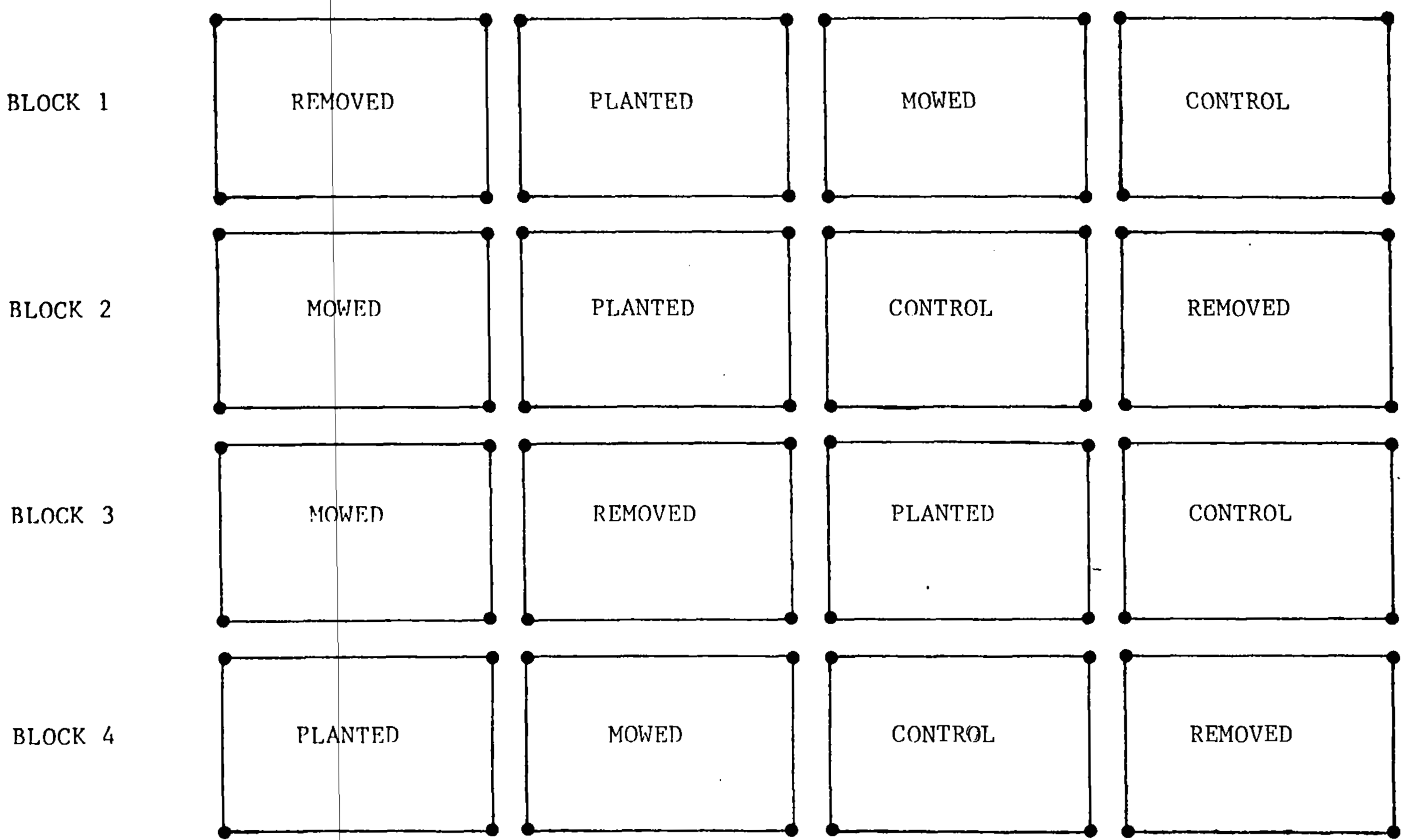

Figure E6. Layout of tree planting experiment at Lincoln Boyhood National Memorial.

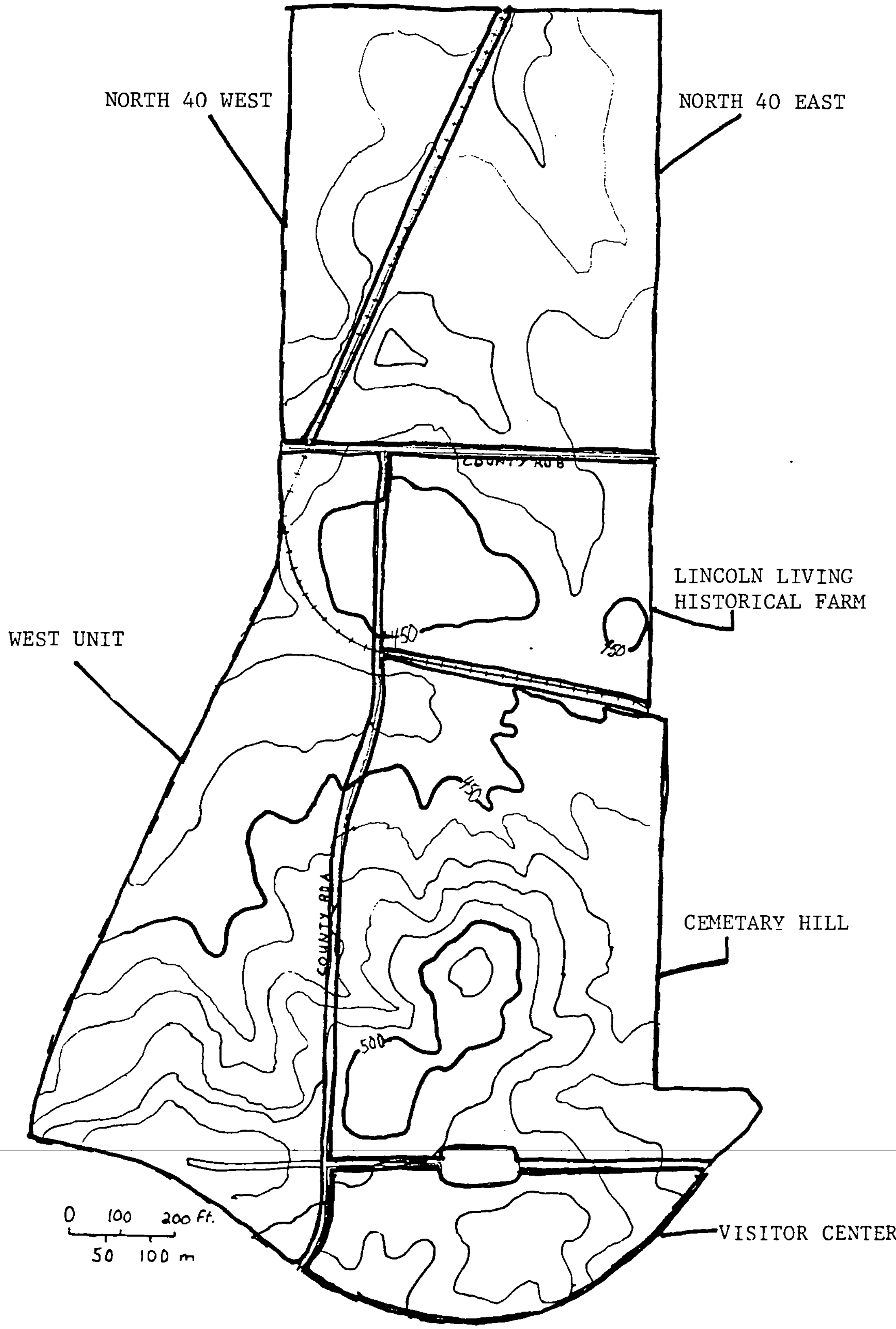

Figure E7. Park units for identifying plant specimen collections.

APPENDIX F. Species planting guidelines

Planting guidelines are necessary for management; however it is difficult to give precise planting densities that will yield a given mature stand density at some future date. Therefore included below are tentative planting densities based on the vegetation samples. Also species that readily invade without human intervention are excluded since it would be a waste of effort and money to plant them. Planting can be done to mimic relict stands presently at or near LBNM.

Bottomland Hardwood Forest

S, F and D correspond respectively to slopes, flats and drainages

A. Overstory	Percentages		Density/acre	
	S	F	S	F
Pin Oak (Quercus palustris) - FD	30	30	90	90
Black Walnut (Juglans nigra) - S	10	5	30	15
American Ash (Fraxinus americana) - SF	5	0	15	0
Bitternut Hickory (Carya cordiformis) - SF	20	15	60	45
Shingle Oak (Quercus imbricaria) - SF	10	10	30	30
Slippery Elm (Ulmus rubra) - SF	5	5	15	7.5
White Oak (Quercus alba) - SF	10	5	30	15
Sweet Gum (Liquidambar styraciflua) - F	2.5	5	7.5	22.5
Black Gum (Nyssa sylvatica) - F	2.5	5	7.5	22.5
Red Maple (Acer rubrum) - SFD	2.5	8	7.5	24
Green Ash (Fraxinus pennsylvanica) - SF	5	5	15	15
Sycamore (Platanus occidentalis) - D	0	2	0	6
River Birch (Betula nigra) - D	0	4	0	12
Cottonwood (Populus deltoides) - D	0	1	0	3

B. Shrub Layer				
Spicebush (Lindera benzoin) - FD	50	60	50	60
Dogwood (Cornus florida) - SF	25	20	25	20
Red cedar (Juniperus virginiana) - SF	15	0	15	0
Sweet Gum (Liquidambar styraciflua) - F	10	20	10	20

C. Herbaceous Layer

Terrell Grass (Elymus virginica) - SFD
White Grass (Leersia virginica) - D
Bedstraw (Galium aparine) - DFS
Touch-me-not (Impatiens capensis) - D
Clearweed (Pilea pumila) - D
Cream Violet (Viola striata) - F
Geranium (Geranium maculatum) - S
White Snakeroot (Eupatorium rugosum) - SF
Scorpion Weed (Phacelia bipinnatifida) - SF
Common Blue Violet (Viola papilionacea) - S
Sedge (Carex squarrosa) - DF
False Nettle (Boehmeria cylindrica) - DF
Thoroughwort (Eupatorium serotinum) - DF
Sensitive Fern (Onoclea sensibilis) - DF

Mixed Hardwood Forest

R, D and F are respectively rises, draws, and flats

A. Overstory

	Percentage			Density/acre		
	R	D	F	R	D	F
White Oak (*Quercus alba*) - DFR	30	35	35	90	105	105
Red Oak (*Quercus rubra*) - DR	5	5	0	15	15	0
Black Oak (*Quercus velutina*) - R	20	5	0	60	15	0
Black Walnut (*Juglans nigra*) - DF	0	2.5	5	0	8	15
Butternut (*Juglans cinerea*) - F	0	0	10	0	0	30
Shagbark Hickory (*Carya ovata*) - DR	20	10	0	60	30	0
Shingle Oak (*Quercus imbricaria*) - DF	0	5	10	0	15	30
Red Maple (*Acer rubrum*) - FD	0	2.5	5	0	8	15
Basswood (*Tilia americana*) - D	0	2.5	0	0	8	0
Pignut Hickory (*Carya glabra*) - DR	10	5	0	30	15	0
White Ash (*Fraxinus americana*) - DR	10	5	0	30	15	0
Green Ash (*Fraxinus pennsylvanica*) - DF	0	2.5	5	0	8	15
Black Cherry (*Prunus serotina*) - DFR	2.5	5	5	8	15	15
Black Gum (*Nyssa sylvatica*) - DF	0	2.5	5	0	8	15
Slippery Elm (*Ulmus rubra*) - DF	0	5	10	0	15	30
Sassafras (*Sassafras albidum*) - DFR gaps	2.5	2.5	2.5	8	8	8
Persimmon (*Diospyros virginiana*) - DF	0	2.5	2.5	0	8	8
Hickory (*Carya ovalis*) - DF	0	2.5	5	0	8	15

B. Shrub Layer

Dogwood (*Cornus florida*) - RDF	40	30	20	40	30	20
Black Haw (*Viburnum prunifolium*) - RD	10	20	10	10	20	10
Pawpaw (*Asimina triloba*) - RDF gaps	10	10	10	10	10	10
Spicebush (*Lindera benzoin*) - DF	5	10	40	5	10	40
Redbud (*Cercis canadensis*) - RD gaps	20	15	10	20	15	10
Redcedar (*Juniperus virginiana*) - RDF gaps	10	10	10	10	10	10
Hop hornbeam (*Ostrya virginiana*) - RD	5	5	0	5	5	0

C. Herbaceous Layer

Bedstraw (*Galium circaezans*) - RDF
Bedstraw (*Galium triflorum*) - RDF
White Snakeroot (*Eupatorium rugosum*) - F
Common Blue Violet (*Viola papilionacea*) - RDF
Avens (*Geum canadense*) - RD
Black Snakeroot (*Sanicula canadensis*) - DR
Clearweed (*Pilea pumila*) - F
Hog Peanut (*Amphicarpa bracteata*) - DF
Virginia Jumpseed (*Tovara virginiana*) - DF
Bluebells (*Mertensia virginica*) - DF
Spring Beauty (*Claytonia virginica*) - R
Miterwort (*Mitella diphylla*) - DF
Ebony Spleenwort (*Asplenium platyneuron*) - F
Grapefern (*Botrychium dissectum tenuifolium*) - RF
Grapefern (*Botrychium dissectum*) - RF

C. Herbaceous Layer contd.

Scorpion Weed (*Phacelia bipinnatifida*) - RD
Smooth Yellow Violet (*Viola pensylvanica*) - DF
Cut-leaf Toothwort (*Dentaria laciniata*) - R
Yellow Troutlily (*Erythronium americanum*) - DF
Jack-in-the-Pulpit (*Arisaema atrorubens*) - DR
Stickseed (*Hackelia virginiana*) - D
Sedge (*Carex* sp.) - RDF

Upland Hardwood Forest

A. Overstory

	Percentage		Density/acre	
	xeric	mesic	xeric	mesic
Black Oak (Quercus velutina)	40	20	120	60
White Oak (Quercus alba)	20	40	60	120
Red Oak (Quercus rubra)	0	5	0	15
Post Oak (Quercus stellata)	5	0	15	0
Chestnut Oak (Quercus muehlenbergii)	0	5	0	15
Shagbark Hickory (Carya ovata)	10	15	30	45
Pignut Hickory (Carya glabra)	15	10	45	30
White Ash (Fraxinus americana)	5	5	15	15
Sassafras (Sassafras albidum)	5	5	15	15
Basswood (Tilia americana) draws	0	5	0	15
Yellow Buckeye (Aesculus glabra) draws	0	5	0	15

B. Shrub Layer

Redbud (Cercis canadensis) gaps	30	40	30	40
Dogwood (Cornus florida)	40	40	40	40
Winged Elm (Ulmus alata)	30	0	30	0
Black Haw (Viburnum prunifolium)	0	10	0	10
Pawpaw (Asimina triloba) gaps	0	10	0	10

C. Herbaceous Layer

Spring Beauty (Claytonia virginica) - mesic and xeric
Geranium (Geranium maculatum) - mesic
Mayapple (Podophyllum peltatum) - mesic
Jack-in-the-Pulpit (Arisaema atrorubens) - mesic
Green Dragon (Arisaema dracontium) - mesic
Prairie Trillium (Trillium recurvatum) - mesic
Yellow Troutlily (Erythronium americanum) - mesic
White Troutlily (E. albidum) - mesic
Cutleaved Toothwort (Dentaria laciniata) - mesic and xeric
Rue Anemone (Anemonella thalictroides) - mesic
Lily-leaved Twayblade (Liparis lilifolia) - mesic
Goldenseal (Hydrastis canadensis) - mesic draws
Common Blue Violet (Viola papilionacea) - mesic and xeric
Solomon's Seal (Polygonatum biflorum) - mesic
Cream Violet (Viola striata) - mesic
Wild Oats (Uniola latifolia) - xeric
Strawberry Bush (Euonymus americana) - mesic
Scorpion Weed (Phacelia bipinnatifida) - mesic
Rattlesnake Fern (Botrychium virginiana) - mesic
Bloodroot (Sanguinaria canadensis) - mesic draws
Yellow Fumewort (Corydalis flavula) - mesic draws

APPENDIX G. Trial Spring Herb Planting Experiment

The figures below were drawn by Shirley Gates who conducted the herb restoration at Lincoln Boyhood National Memorial . Her results are encouraging for the successful reintroduction of spring ephemeral herbs, especially since 1988 was such a dry year.

FIGURE G1 - Location of experimental plots.

FIGURE G2 - Plot diagrams illustrating which species were alive in 1989.

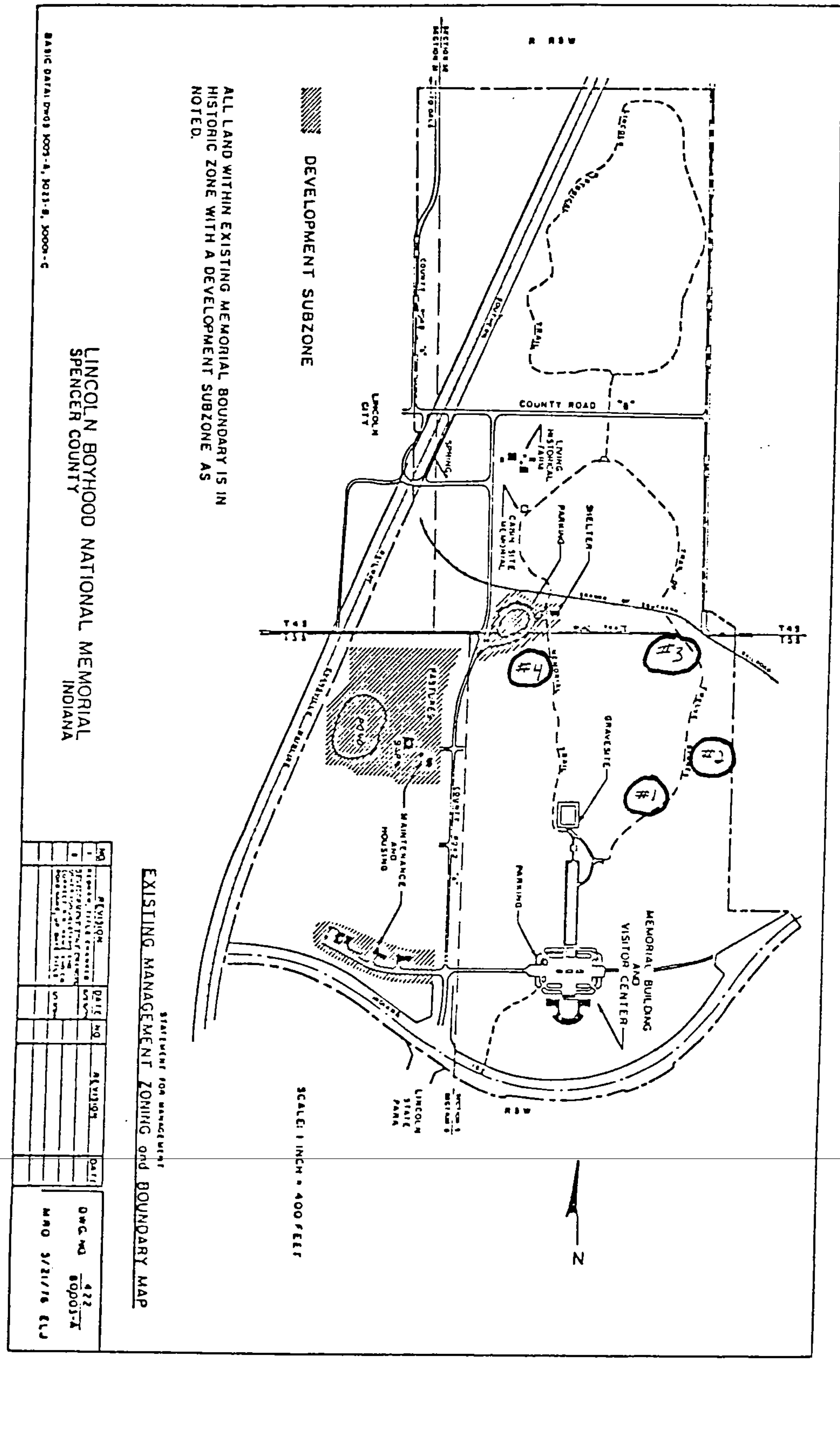

Figure G1. Location of experimental plots.

EXPERIMENTAL PLOTS

Key:

- V =Pale Yellow Violet plants
- =Cut-leaved Toothwort seeds
- =Spring Beauty seeds
- =Virginia Bluebells seeds
- RA =Rue Anemone seeds
- Bs =Bloodroot seeds
- SS =Rough Solomon's Seal seeds
- JP =Jack-in-the-Pulpit
- Br =Bloodroot roots
- **=Alive on April 20,1989**

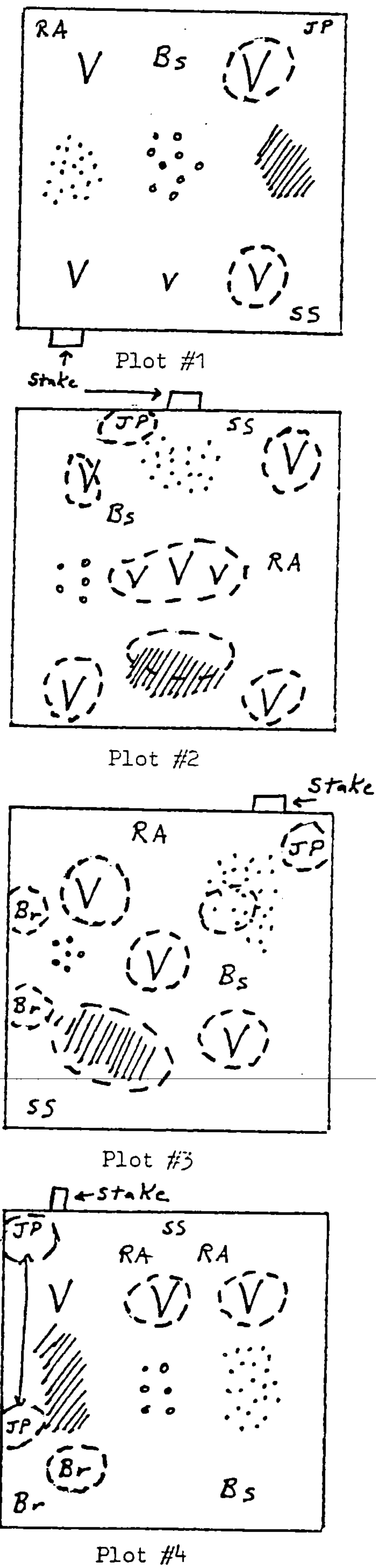

Figure G2. Plot diagrams illustrating which species were alive in 1989.

Appendix H. Plant Species List for Lincoln Boyhood National Memorial.

This plant list is incomplete and any errors are ours. Nomenclature follows Fernald (1970). Plant specimens collected were housed in the LBNM herbarium. The codes following the common species names are respectively:

- E - exotic.
- F - species is grown on the Living Historical Farm.
- SP - species grows in the Lincoln State Park Woods.
- ? - occurrence is unknown.

ASPLENIACEAE

Asplenium platyneuron (L.) Oakesex D.C. Eat.(Ebony Spleenwort)
Cystopteris fragilis (L.) Bernh. (Fragile Fern)
Onoclea sensibilis L. (Sensitive Fern)

OPHIOGLOSSACEAE

Botrychium dissectum Spreng (Grape Fern)
Botrychium dissectum Spreng. *tenuifolium* (Underw.) Farw. (B. biternatum) (Grape Fern)
Botrychium virginianum (L.) Sw. (Rattlesnake Fern)

LYCOPODIACEAE

Lycopodium complanatum L. *flabelliforme* Fern. (Ground Pine)

PINACEAE

Juniperus virginiana L. (Red Cedar)
Picea abies (L.) Karst. (Norway Spruce) E
Pinus rigida Mill. (Pitch Pine) E
Pinus strobus L. (White Pine) E
Pseudotsuga menxiesii (Mirb.) Franco (Douglas Fir) E
Taxodium distichum (L.) Richard (Bald Cypress) E
Thuja occidentalis L. (White Cedar) E

ACANTHACEAE

Ruellia caroliniensis (Walt.) Steud. (Carolinian Ruellia)

ACERACEAE

Acer negundo L. (Boxelder)
Acer nigrum Michx. f. (Black Maple)
Acer rubrum L. (Red Maple)
Acer saccharinum L. (Silver Maple)
Acer saccharum Marsh. (Sugar Maple) E?

ANACARDIACEAE

Rhus copallina L. (Shining Sumac)
Rhus glabra L. (Smooth Sumac)
Rhus radicans L. (Poison Ivy)
Rhus typhina L. (Staghorn Sumac)

ANNONACEAE

Asimina triloba (L.) Dunal (Pawpaw)

APIACEAE

Anethum graveolens L. (Dill) E F
Chaerophyllum procumbens (L.) Crantz var. procumbens
Cryptotaenia canadensis (L.) DC. (Honewort)
Daucus carota L. (Wild Carrot)
Sanicula canadensis L. (Black Snakeroot)

APOCYNACEAE

Apocynum cannabinum L. var. glaberrimum A. DC. (Indian Hemp)

Vinca minor L. (Periwinkle) E.

ARACEAE

Arisaema dracontium (L.) Schott (Green Dragon)

Arisaema atrorubens (Ait.) Blume (Jack-in-the-Pulpit)

ASCLEPIADACEAE

Asclepias syriaca L. (Common Milkweed)

Asclepias tuberosa L. (Butterfly Weed)

ASTERACEAE

Achillea millefolium L. (Yarrow)

Ambrosia artemisiifolia L. var. elatior Descourtils (Ragweed)

Ambrosia bidentata Michx. (Ragweed)

Ambrosia trifida L. (Great Ragweed)

Antennaria plantaginifolia (L.) Richards (Pussytoes)

Artemisia ludiviciana Nutt. (Western Mugwort)

Aster cordifolius L. ?

Aster drummondii Lindl. ?

Aster patens Ait. ?

Aster pilosus Willd. var. demotus Blake ?

Aster shortii Lindl. ?

Aster undulatus L. ?

Aster vimineus Lam. ?

Bidens aristosa (Michx.) Britt. var. aristosa

Bidens vulgata Greene (Beggars Tick)

Boltonia asteroides (L.) L'Her (Boltonia)

Chrysanthemum leucanthemum L. (Ox-eye Daisy) E

Erechtites hieraciifolia (L.) Raf. ex DC. (Fireweed)

Erigeron annuus (L.) Pers. (Daisy Fleabane)

Erigeron strigosus Muhl. ex Willd. var. strigosus (Daisy Fleabane)

Eupatorium coelestinum L. (Ageratum)

Eupatorium hyssopifolium L. (Hyssop-leaved Thoroughwort)

Eupatorium perfoliatum L. (Boneset)

Eupatorium rugosum Houtt. (White Snakeroot)

Eupatorium serotinum Michx.

Gnaphalium sp. (Cudweed)

Kuhnia euparotioides L. (False Boneset)

Matricaria matricariodes (Less.) Porter (Pineapple-weed) E

Rudbeckia hirta L. (Black-eyed Susan)

Senecio aureus L. (Golden Ragwort)

Solidago altissima L. (Tall Goldenrod)

Solidago graminifolia (L.) Nutt. ex Cass. var. nuttallii (Greene) W. Stone = Euthamia graminifolia (L.) Nutt.

Solidago gymnospermoides (Greene) Fern. = Euthamia gymnospermoides Greene

Solidago juncea Ait. Early Goldenrod)

Solidago nemoralis Ait. var. nemoralis (Old-field Goldenrod)

Taraxacum officinale L. (Dandelion) E

Vernonia noviboracensis (L.) Michx. (Ironweed)

BALSAMINACEAE

Impatiens capensis Meerb. (Touch-me-not)

BERBERIDACEAE

Berberis thunbergii DC. (Japanese Barberry) E

Podophyllum peltatum L. (Mayapple)

BETULACEAE

Betula nigra L. (River Birch)

Betula papyrifera Marsh. (Paper Birch) E

Carpinus caroliniana Walt. (Blue Beech)

Corylus americana Walt. (Hazelnut)

Ostrya virginiana (Mill.) K. Koch (Ironwood)

BIGNONIACEAE

Campsis radicans (L.) Seem. ex Bureau (Trumpet Creeper)

Catalpa speciosa Warder (Catalpa) E

BORAGINACEAE

Cynoglossum virginianum L. (Hound's-Tongue)

Hackelia virginiana (L.) I.M. Johnston (Stickseed)

Mertensia virginica (L.) Pers. ex Link (Bluebells)

BRASSICACEAE

Barbarea vulgaris R. Br. (Winter Cress)

Brassica rapa L. ssp. olifera DC.

Capsella bursa-pastoris (L.) Medic. (Shepherd's Purse) E

Cardamine douglassii (Torr.) Britt. (Toothwort)

Dentaria laciniata Muhl. ex Willd. (Cut-leaved Toothwort)

CAMPANULACEAE

Lobelia siphilitica L. (Giant Lobelia)

CAPRIFOLIACEAE

Lonicera japonica Thunb. (Japanese Honeysuckle) E

Sambucus canadensis L. var. canadensis (Elderberry)

Symphoricarpos orbiculatus Moench (Coralberry)

Viburnum dentatum L. var. deamii (Rehd.) Fern. (Southern Arrowoood)

Viburnum prunifolium L. (Blackhaw)

CARYOPHYLLACEAE

Stellaria media (L.) Vill. (Common Chickweed)

CELASTRACEAE

Celastrus scandens L. (Bittersweet)

Euonymus americanus L. (Strawberry Bush)

CLUSIACEAE

Hypericum canadense L. (St John's-wort)

Hypericum denticulatum Walt. var. denticulatum (St John's-wort)

COMMELINACEAE

Commelina communis L. (Dayflower) E

CONVOLVULACEAE

Ipomoea hederacea (L.) Jacq. (Morning Glory) E

CORNACEAE

Cornus florida L. (Dogwood)

CYPERACEAE

Carex amphibola Steud. var. turgida Fern. (Sedge)

Carex annectatens Bickn. (Sedge)

Carex complanata Torr. & Hook (Sedge)

Carex grayi Carey (Sedge)

Carex squarrosa L. (Sedge)

Cyperus strigosus L. (Sedge)

Eleocharis obtusa (Willd.) Schultes (Spike Rush)

CYPERACEAE contd.

Fimbristylis autumnalis (L.) Roemer & Schultes (Sedge)

Scirpus atrovirens Willd. (Bulrush)

DIOSCOREACEAE

Dioscorea battatus Dcne. (Chinese Yam) E

EBENACEAE

Diospyros virginiana L. (Persimmon)

ERICACEAE

Monotropa uniflora L. (Indian Pipe)

EUPHORBIACEAE

Acalypha rhomboidea Raf. (Three-seeded Mercury)

Euphorbia sp. (Spurge)

FABACEAE

Albizzia Julibrissus Durazzini (Mimosa) E

Amphicarpa bracteata (L.) Fern. (Hog Peanut)

Cassia fasciculata Michx. (Sensitive Plant)

Cercis canadensis L. (Redbud)

Desmodium paniculatum (L.) DC (Tick Trefoil)

Gleditsia triacanthos L. (Honey Locust)

Lespedeza cuneata (Dumont) G. Don (Bush-clover) E

Lespedeza striata (Thunb.) H. & A. (Bush-clover) E

Lespedeza virginica (L.) Britt. (Bush-clover)

Melilotus alba Ders. (White Sweet Clover) E

Melilotus officinalis (L.) Pallas (Yellow Sweet Clover) E

Robinia pseudo-acacia L. (Black Locust)

Trifolium dubium Sibth.

Trifolium procumbens L. (Low Hop CLover)

Trifolium repens L. (White Clover) E

FAGACEAE

Castanea dentata (Marsh.) Borkh. (Chestnut) E

Quercus alba L. (White Oak)

Quercus imbricaria Michx. (Shingle Oak)

Quercus muehlenbergii Engelm. (Chestnut Oak)

Quercus palustris Muenchh. (Pin Oak)

Quercus rubra L. (Red Oak)

Quercus stellata Wang. (Post Oak)

Quercus velutina Lam. (Black Oak)

GENTIANACEAE

Sabatia angularis (L.) Pursh. (Rose-pink)

GERANIACEAE

Geranium maculatum L. (Common Geranium)

HAMAMELIDACEAE

Liquidambar styraciflua L. (Sweet Gum)

HIPPOCASTANACEAE

Aesculus glabra Willd. (Yellow Buckeye)

HYDROPHYLLACEAE

Phacelia bipinnatifida Michx. (Scorpion Weed)

JUGLANDACEAE

Carya cordiformis (Wang.) K. Koch (Bitternut Hickory)

Carya glabra (Mill) Sweet (Pignut Hickory)

Carya laciniosa (Michx. f.) Loud. (Big Shellbark)

Carya ovalis (Wang.) Sarg. (Sweet Pignut Hickory)

JUGLANDACEAE contd.

Carya ovata (P. Mill.) K. Koch (Shagbark Hickory)
Carya tomentosa Nutt. (Mockernut Hickory)
Juglans cinerea L. (Butternut)
Juglans nigra L. (Black Walnut)
Juglans regia (English Walnut) EF

JUNCACEAE

Juncus tenuis Willd. var. *tenuis* (Rush)

LAMIACEAE

Glechoma hederacea L. (Gill-over-the-Ground)
Lamium amplexicaule L. (Henbit) E
Marrubium vulgare L. (Common Horehound) EF
Melissa officinalis L. (Common Balm) EF
Mentha piperita L. (Peppermint) EF
Mentha spicata L. (Spearmint) EF
Nepeta cataria L. (Catnip) EF
Prunella vulgaris L. var. *elongata* Benth. (Healall)
Pycnanthemum tenuifolium Shrad (Mountain Mint)
Salvia lyrata L. (Lyre-leaved Sage)
Satureja hortensis L. (Summer-savory) EF
Thymus vulgaris (Thyme) EF

LAURACEAE

Lindera benzoin (L.) Blume (Spicebush)
Sassafras albidum (Nutt.) Nees (Sassafras)

LILIACEAE

Allium canadense L. (Wild Garlic)
Camassia scilloides (Raf.) Cory
Erythronium albidum Nutt. (White Troutlily)
Erythronium americanum Ker-Gawl. (Yellow Troutlily)
Hemerocallis fulva L. (Orange daylily) E
Polygonatum biflorum (Walt.) Ell. (Solomon's Seal)
Smilacina racemosa (L.) Desf. (False Solomon's Seal)
Trillium recurvatum Beck (Prairie Trillium)

LINACEAE

Linum virginianum L. (Flax)

MAGNOLIACEAE

Liriodendron tulipifera L. (Tulip-tree) E?

MENISPERMACEAE

Menispermum canadense L. (Moonseed)

MORACEAE

Morus alba L. (White Mulberry)
Morus rubra L. (Red Mulberry)

NYSSACEAE

Nyssa sylvatica Marsh. var. *sylvatica* (Black Gum)

OLEACEAE

Fraxinus americana L. (White Ash)
Fraxinus americana L. var. *biltmoreana* (Beadle) J. Wright ex Fern.
Fraxinus pennsylvanica Marsh. (Green Ash)
Ligustrum obtusifolium Sieb. & Zucc. (Privet) E
Ligustrum vulgare L. (Common Privet) E
Syringa vulgaris L. (Common Lilac) E

ONAGRACEAE

Ludwigia alternifolia L. (Seedbox)

Oenothera biennis L. ssp. *biennis* (Evening Primrose)

ORCHIDACEAE

Liparis lilifolia (L.) L. C. Rich. ex Lindl. (Lily-leaved Twayblade)

Platanthera peramoena (Gray) Gray (Purple Fringeless Orchis)

Spiranthes ovalis Lindl. (Ladies' Tresses)

OXALIDACEAE

Oxalis europaea Jord. f. *villicaulis* Wieg. (European Wood Sorrel)

Oxalis stricta L. var. *stricta*

Oxalis violacea L. var. *violacea* (Wood Sorrel)

PAPAVERACEAE

Corydalis flavula (Raf.) DC. (Yellow Fumewort)

Sanguinaria canadensis L. (Bloodroot) SP

PHYTOLACCACEAE

Phytolacca americana L. (Pokeweed)

PLANTAGINACEAE

Plantago lanceolata L. (Plantain)

Plantago major L. (Plantain)

PLATANACEAE

Platanus occidentalis L. (Sycamore)

POACEAE

Andropogon virginicus L. (Broomsedge)

Andropogon scoparius Michx. (Little Bluestem)

Aristida oligantha Michx.

Aristida ramosissima Engelm. (Needle Grass)

Bromus japonicus Thunb. ex Murr.

Bromus racemosus L. (Brome-Grass) E

Cinna arundinacea L.

Dactylis glomerata L. (Orchard Grass) E

Danthonia spicata (L.) Beauv. ex Roemer & Schultes

Diarrhena americana Beauv.

Digitaria ischaemum (Schreb. ex Schweig) Schreb. ex Muhl. (Small Crabgrass)

Digitaria sanguinalis (L.) Scop. (Crabgrass)

Elymus virginicus L. var. *virginicus* (Terrell Grass)

Festuca elatior L. (Meadow Fescue) E

Festuca obtusa Biehler (Fescue)

Festuca rubra L. (Red Fescue) E

Glyceria striata (Lam.) A.S. Hitchc. (Fowl Meadowgrass)

Hystrix patula Moench (Bottlebrush Grass)

Leersia virginica Willd. (Whitegrass)

Panicum anceps Michx.

Panicum clandestinum (L.) Gould

Panicum lanuginosum Ell. (Panic Grass)

Paspalum ciliatifolium Michx.

Paspalum laeve Michx. var. *circulare* (Nash) Fern. (Knotgrass)

Phleum pratense L. (Timothy) E

Poa compressa L. (Canada Bluegrass) E

Poa pratensis L. (Kentucky Bluegrass)

Setaria geniculata (Lam.) Beauv. (Foxtail Grass)

Triodia flava (L.) Smyth (Red Top) = *Tridens flavus* (L.) A.S. Hitchc.

POACEAE contd.

Uniola latifolia Michx. (Wild Oats)
Vulpia octoflora (Walt.) Rydb. var. octoflora

POLEMONIACEAE

Phlox divaricata L. (Blue Phlox)

POLYGALACEAE

Polygala sanguinea L. (Milkwort)

POLYGONACEAE

Polygonum cespitosum Blume (Knotweed) E
Polygonum cuspidatum Sieb. & Zucc. (Japanese Knotweed) E
Polygonum scandens L. (Climbing False Buckwheat)
Rumex acetosella L. (Sheep Sorrel) E
Tovara virginiana (L.) Raf. (Virginia Jumpseed)

PORTULACACEAE

Claytonia virginica L. (Spring Beauty)

RANUNCULACEAE

Anemonella thalictroides (L.) Spach. (Rue-Anemone)
Clematis virginiana L. (Virginia Bower)
Hydrastis canadensis L. (Golden-Seal)
Isopyrum biternatum (Raf.) Torr. & Gray
Ranunculus recurvatus Poir. (Recurved Buttercup)

RHAMNACEAE

Rhamnus lanceolata Pursh. (Buckthorn)

ROSACEAE

Agrimonia sp
Fragaria virginiana Duchesne (Strawberry)
Geum canadense Jacq. (Avens)
Malus coronaria (L.) P. Mill. var. coronaria
Potentilla simplex Michx. var. simplex (Cinquefoil)
Prunus serotina Ehrh. (Black Cherry)
Prunus virginiana L. (Choke Cherry)
Rubus sp. (Blackberry)
Spiraea alba Du Roi. (Steeplebush)
Spiraea cantoniensis Lour. (Spirea) E

RUBIACEAE

Cephalanthus occidentalis L. (Buttonbush)
Diodia teres Walt. (Buttonweed)
Galium aparine L. (Bedstraw)
Galium circaezans Michx. var. hypomalacum Fern. (Bedstraw)
Galium concinnum Torr. & Gray (Bedstraw)
Galium triflorum Michx. (Bedstraw)
Houstonia caerulea L. (Bluets)

SALICACEAE

Populus deltoides Bartr. ex Marsh. (Cottonwood)

SAXIFRAGACEAE

Hydrangea arborescens L. (Wild Hydrangea)
Philadelphus coronarius L. (Mock-Orange) E

SCROPHULARIACEAE

Mimulus alatus Ait.
Penstemon digitalis Nutt. (Beard-Tongue)
Verbascum thapsus L. (Mullen) E
Veronica arvensis L. E

SMILACACEAE

- Smilax glauca Walt. var. glauca
- Smilax hispida Muhl.
- Smilax lasioneuron Hook.
- Smilax rotundifolia L.

SOLANACEAE

- Capsicum sp. (Bell Pepper) EF
- Nicotiana tabacum L. (Tobacco) EF
- Solanum carolinense L. (Horse-Nettle)

TILIACEAE

- Tilia americana L. (Basswood)

ULMACEAE

- Celtis occidentalis L. (Hackberry)
- Ulmus alata Michx. (Winged Elm)
- Ulmus americana L. (American Elm)
- Ulmus rubra Muhl. (Slippery Elm)

URTICACEAE

- Boehmeria cylindrica (L.) Sw. var. cylindrica (False Nettle)
- Pilea pumila (L.) Gray (Clearweed)
- Urtica dioica L. (Nettle)

VERBENACEAE

- Phryma leptostachya L. (Lopseed)

VIOLACEAE

- Viola pensylvanica Michx. (Smooth Yellow Violet)
- Viola pubescens Ait. var. eriocarpa (Schwein.) Russell (Downy Yellow Violet)
- Viola striata Ait. (Cream Violet)

VITACEAE

- Parthenocissus quinquefolia (L.) Planch. (Virginia Creeper)
- Vitis riparia Michx. (River Grape)

The National Park Service's Midwest Region covers 33 park units located in 10 states in the Great Plains and Great Lakes area (Nebraska, Kansas, Missouri, Iowa, Minnesota, Wisconsin, Michigan, Illinois, Indiana, and Ohio). The physical and biological diversity of the Region is reflected in the variety of research conducted in the parks. Current research subjects range from a survey of prairie vegetation in several small parks to the ecology of boreal forests at Voyageurs; from threatened plants in a number of parks to endangered wolves at Isle Royale; from hydrology of springs at Ozark to air pollution at Indiana Dunes; and from recreational boating use patterns on the Lower Saint Croix to hiking and campground use at Isle Royale. For more information on the National Park Service's Midwest Regional science program, please write:

Regional Chief Scientist
National Park Service
Midwest Regional Office
1709 Jackson Street
Omaha, Nebraska 68102

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environment and cultural value of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.